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TREES

A HANDBOOK OF FOREST-BOTANY FOR THE WOODLANDS AND THE LABORATORY

BY

H. MARSHALL WARD, Sc.D., F.R.S.,

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Author of *The Oak; Timber and some of its Diseases; Grasses; Disease in Plants;* &c.

VOLUME III.

FLOWERS AND INFLORESCENCES.

WITH ILLUSTRATIONS

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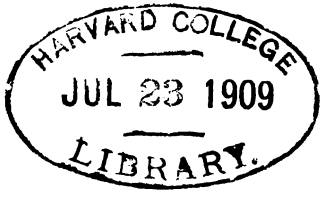

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PREFACE.

THE first and second volumes of this work dealt respectively with "Buds and Twigs" and with "Leaves," and in each case it was incumbent on me to invent a special scheme of classification by means of which the reader should be able to identify our native and commonly introduced Trees and Shrubs in the Winter or at other seasons when they are devoid of Flowers.

Indeed Volume I., on "Buds and Twigs," is essentially and particularly a book for the Winter-study of Trees, to enable the student to recognise even deciduous woody plants by such marks as the leaf-scars, bud-scales, position and structure of buds, and so forth. Volume II., on "Leaves," on the other hand, is concerned entirely with the study of foliage, and especially at periods when, as in Spring and Autumn, or at ages when the tree is still too young to bear flowers and fruit, the characters of the leaves and other vegetative organs are alone available for diagnosis.

In the present Volume, the third of the series of six of which this work will consist, I have designed what may be regarded as emphatically a book for the Summer.

It is devoted to the close study of the Inflorescence and Flowers of our Trees and Shrubs, and since the Natural System of Classification, now in use all over the world, is based on this study of the floral organs, the Scheme of Classification here employed retains all the essentials of that system, and that in proper order. Hence the student will here find an epitome of the Natural System illustrated by critical studies of Woody Plants.

It would obviously be absurd to pretend that such an epitome could be prepared entirely devoid of technicalities. I have, however, so carefully guarded every avenue to reproach on this score, that it is confidently anticipated that even the amateur reader and botanist will exonerate me from blame: it is absolutely inexpedient, and often impossible, to avoid the use of words like *Hypogynous*, *Dichlamydeous*, *Calyciflorœ*, *Gamopetalous* and so forth, just as it would be impracticable to attempt to obviate words like *Port*, *Helm*, *Hawser*, *Painter*, &c., in seamanship. Such terms are justified by the clear ideas they denote and by the time they save in speaking and writing; and strictly speaking it would be as reasonable to refuse to term a flower, of which the parts of the Corolla have all grown up into one whole, "*Gamopetalous*," as it would be to try to avoid the technical term "*Handle-bar*" or "*Gear-case*" for a now well known part of a Bicycle.

In order that even the uninitiated may read the book without fear of the technical terms, moreover, I have

written the general preliminary part in language as simple as possible, and have appended a very full Glossary in addition to a complete Index.

I venture to call attention to a feature of the book which may prove of considerable value to the Forest-botanist. As is well known, the Willows are in any case a very difficult group, even for the expert, and their difficulties are increased when, as often happens, the collector finds only the staminate or only the pistillate flowers available. In order to minimise these difficulties I have added, in an Appendix, a supplementary table of classification by characters derived from the staminate, or from the pistillate flowers respectively.

For the rest, it may suffice to point out the very thorough and detailed descriptions and illustrations of the Forest-trees especially, the small green and complex inflorescences and flowers of which are so often overlooked, or inadequately dealt with, in text-books and Floras. A careful study of their morphology will open up to the student new delights in several directions. The same also applies to the Conifers, a group far too little known to English students.

In the treatment of the difficult subject of Inflorescences, the reader will find everything making for simplicity: the more involved Cymose inflorescences being rarely found in the plants here concerned. At the same time I have introduced sufficient concerning morphology and development to make the study of more difficult forms intelligible.

The same remarks also apply to the morphology and development of the Flower, the subject of which must here be necessarily dealt with in a mere sketch.

The student will find the subject of pollen and pollination by Insects, Wind, &c., also dealt with in a general but, I hope, satisfactory and efficient manner suitable to the purposes of the book.

The lettering denoting acknowledgement of the woodcuts is as in previous volumes, and the Bibliography at the end of the book shows whence further facts may be obtained.

As in previous volumes the making of the Index, here a truly laborious task, has been again done by my wife.

H. MARSHALL WARD.

CAMBRIDGE, *April* 1905.

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PART I.

GENERAL.

CHAPTER I.

FLOWERS AND FLOWERING.

Flowers and Flower-buds—Inflorescence—Definition of Flower—Essential and Non-essential Organs—Stamens and Pollen—Carpels and Ovules—Seeds—Petals and Sepals—Inflorescence-Bracts—Period of flowering—List of trees and their flowering.

ALL ordinary trees and shrubs, such as those here concerned, attain at length to a period during which some of the buds alter their characters, to the extent that the leaf-incepts formed on the flanks of the shoot-apex no longer develope into typical foliage-leaves and bud-scales, but into organs whose functions are more or less directly adapted for the propagation of the species. Although these organs are still, morphologically, leaves, and notwithstanding the fact that their form, colouring, texture, venation, &c., depart but little, or even not at all, from those of green leaves, observation shows that they serve in less and less degree the function of assimilation or photo-synthesis, and are more and more especially adapted to that of reproduction.

The collection of such organs, at the end of the shoot, is termed a Flower. In the bud-state, it is a Flower-bud; and the special branches of the shoot bearing such flower-buds, or flowers, are known as the Inflorescence, or flowering shoots.

As a rule it is not difficult to recognise the flower-buds, or the buds containing inflorescences, by certain peculiarities of size, shape, or colouring and other characters, even at a time when the young organs within the buds are as yet hardly shaped, or differentiated, in any way distinctive from young leaf-incepts; but cases occur where appreciative characters of difference are lacking, or almost lacking, and the flower-buds resemble the leaf-buds so closely that their fundamental morphological similarities are manifest.

Moreover, the flowers and inflorescences of different trees and shrubs differ conspicuously in complexity, as we shall see; and the most general statement we can make to cover all the cases is, that the flower is essentially a shoot-axis bearing lateral appendages on or in which are bodies containing the true reproductive organs. To these—the essential organs of the flower—there may be added certain more evidently foliar organs, which serve to cover in and protect the essential structures; but since such are not always present they are termed the non-essential parts of the flower.

The essential organs are the *Stamens* and the *Carpels*: the former containing the powdery grains, which are generally yellow and separate out like dust, known as *Pollen*; the latter bearing peculiar, usually more or less rounded, bodies known as *Ovules*, which will eventually ripen as the *Seeds*.

No structure can properly be termed a flower that does not consist of either one or more stamens, or of one or more carpels; though, as we shall see, the stamens and carpels are not necessarily borne in the same flower or inflorescence, or even on the same tree.

The non-essential organs are protective or attractive, and may be very elaborate structures indeed. In their more typically developed forms they usually occur as an

inner series of expanded, delicate, and coloured structures termed *Petals*, and of an outer series of green and more leaf-like structures known as *Sepals*; but so many peculiar modifications of these interesting organs occur, that they must be treated in more detail later on, and I must confine myself here to repeating that neither petals nor sepals are essential parts of the flower, and to stating that either or both may be associated with either or both of the essential organs.

It is a remarkable fact that the shoots or branches which immediately bear the flowers, frequently, and indeed usually, differ in certain respects from those bearing the foliage only, and in some cases the alterations go so far that the beginner may not recognise these parts of the plant as belonging to the shoot.

In the commonest cases the differences consist chiefly in departures from the mode of branching prevalent elsewhere on the plant; in alterations in the length, thickness, &c., of the internodes; and in changes of disposition, form, and colouring, &c., of the leaves borne in the neighbourhood of the flowers.

This floral branch-system is known collectively as the *Inflorescence*; and the leaves more immediately associated with the inflorescence and flowers are termed *Bracts* and *Bracteoles*.

Before passing to the more detailed description of the foregoing structures, it will be useful to point out that the period of flowering differs considerably in different plants, and particularly in the case of trees and shrubs.

The power to form flowers is found to be in some way essentially bound up with the power of the plant to lay by stores of reserve-materials, food-stuffs not wanted for its immediate needs in the formation of wood, leaves, &c.; but it is also evident that such power is dependent to some

extent on external circumstances such as we term, in the aggregate, season, climate, and weather.

Some herbaceous plants will flower a few weeks after sowing, and repeated crops may be obtained in one year. At the other extreme are trees which do not flower until they are fifty or sixty years old, and then die. Many of our ordinary shrubs only commence to bear flowers after from two or three to eight or ten years; while trees are usually much older before they bear flowers capable of yielding seed.

The following list gives the approximate age of flowering in certain of our common trees:

Ash, 20 to 25, or even 40 years.
White Poplar, 10 years.
Aspen, 10 to 20, or even 25 years.
Lime, 15 to 20, or even 30 years.
Sycamore, 10 to 25, or even 30 years.
Norway Maple, 10 to 15 or 20, or even 40 years.
Horse-chestnut, 15 to 20 years.
Beech, 40 to 50, or even 60 to 80 years.
Chestnut, 6 to 10, up to 20 or 30, or even 40 to 60 years.
Oak, 20 to 50 or 60, or even 80 to 100 years.
Holme Oak, 8 to 10 years.
Cork Oak, 15 to 30 years.
Hazel, 5 to 10 years, or even earlier.
Hornbeam, 15 to 20 years.
Birch, 8 to 10, up to 20, or even 30 years.
Alder, 12 to 20, up to 35, or even 40 years.
Spruce, 15 or less, up to 50, or even 70 years.
Cedar, 30 to 40 years.
Scots Pine, 15 to 20, up to 30 or 40, or even 70 to 80 years.
Mountain Pine, 6 to 10 years.
Austrian Pine, 15 to 30 years.
Cluster Pine, 15 to 20 years.
Arolla Pine, 25 to 50, or even 60 years.
Weymouth Pine, 25 to 50 years.
Stone Pine, 20 to 40, or even 60 years.

Silver Fir, 30 to 60, or even 70 years.
Larch, 15 to 30 years.
Yew, 20 years.
Some Willows will bear flowers when 2—3 years old.

Where the differences are great, the lowest numbers refer to dry, poor soils in the open; the medium numbers to well-grown isolated trees; and the highest to trees crowded in forests or plantations, &c. In many cases the flowers are barren during the earlier years of flowering; and it is a common result that a heavy crop of fertile flowers, resulting in exhaustion of the stores of reserve-materials, is followed by two or three years without flowers, a fact well known also to fruit growers.

Individual trees occasionally bear flowers much earlier than the normal age, especially such as are growing in poor, hot soils, or from coppice.

CHAPTER II.

THE INFLORESCENCE.

Branching—Monopodial and Sympodial—False Dichotomy—Simple Monopodial Axis—Peduncle and Pedicel—Bracts—Relations between Acropetal, Monopodial and Indefinite development—Raceme and Racemose type—Sympodial Axis—Definite and Cymose Inflorescences—Difficulties of Analysis—Mixed Inflorescences—Uniaxial and Multiaxial types—Illustrations.

WHILE it is true that any generalisations as to branching apply to all parts of the shoot, the subject has acquired a peculiar importance in that region which produces the flowers. This floriferous branch-system is termed the Inflorescence, and it is usually conspicuously different from the rest of the shoot in the smallness of its leaves (Bracts and Bracteoles), the slenderness of its internodes if they are elongated, and of course in the presence of the flowers and flower-buds.

No case of truly dichotomous branching occurs in flowering plants, so that we are only concerned with ordinary branch-systems (monopodial and sympodial) in the Inflorescence; nevertheless, as will be seen, false dichotomy and other puzzling appearances may be brought about by local peculiarities of growth, and mixtures of both systems may lead to complications of other kinds.

If we suppose a bud to develope into a shoot by

means of the continued growth of the apex, putting out lateral leaves and buds in succession as it elongates —in the manner described in Volume I. pp. 64–75—it is clear that the axis thus produced is one continuous whole. It matters not what may be the nature of the outgrowths developed laterally on this axis; the fact remains that it is a single, continuous one, and its onward growth may be roughly compared with the pulling out of the successive joints of a telescope, each segment representing an internode, and each joint a node. A continued, single mother-axis of this kind is termed a *Monopodium*—i.e. a simple axis as contrasted with one made up of intermittent growths (Fig. 1).

Such an elongated axis, bearing a small leaf at each node and a flower on a little stalk in the axil of each leaf, would be a very simple form of inflorescence. The long axis would here be called the *Peduncle*, and each small lateral flower-stalk would be termed a *Pedicel*; while the small leaves, in the axils of which the pedicels arise, are known as *Bracts*—i.e. leaves, usually of smaller size than the ordinary foliage-leaves and of different shape from them, as well as being closely associated with the flowers. This mother-axis, or peduncle, goes on growing during the greater part of the period of flowering, and therefore indefinitely, as it were, within this period; which moreover may be a very long one. For this reason such an inflorescence is often termed *indefinite*; and the term, though relative, is useful.

During this prolonged period it puts out new flower-buds near its apex, while those already formed lower down on its sides go on expanding and perfecting themselves in succession. In other words, the youngest flowers are at the top of the axis, and the oldest are at the base, their sequence being such that every flower is one stage further

advanced, in age and relative completeness, than the one above it.

In other words, the order of completion of the flowers proceeds from above downwards along the mother-axis or peduncle. The same is true of the bracts: each one lower down is nearer its period of maturity or death than the one next above it.

Such an order of successive development, where each lateral organ (here especially the flowers) on the mother-axis is the younger the nearer it is to the onward-growing apex, is termed *Acropetal.*

On reviewing the above, we see that a simple inflorescence of the kind described is *Monopodial* in virtue of the fact that its principal axis is a single on-growing one; it is *Indefinite* in the sense that its onward growth is continued through a relatively long period, and not stopped by the formation of a flower at the extreme apex at a relatively early stage; and it is *Acropetal* with respect to the order of maturity of the flowers along its course, the observer's eye having to pass from the base towards the apex as he seeks younger and younger flowers and flower-buds (Fig. 1).

We shall see shortly that an inflorescence such as that described is, as regards its particular form, termed a *Raceme*; whence such monopodial, acropetal, and indefinite inflorescences are often termed *racemose* inflorescences, a useful descriptive general term for employment in the field.

Let us now suppose an opening bud to give rise to an elongating shoot as before, but that the onward growth is soon arrested by the formation of a terminal flower (Fig. 2, A 1), while below its apex a bract is formed in the axil of which a lateral branch is borne, the growth of which is similarly soon arrested by its termination in a

flower (Fig. 2, A 2); a third lateral branch, also rapidly terminating in a flower, is in the same way borne in the axil of a bract on this, and so on.

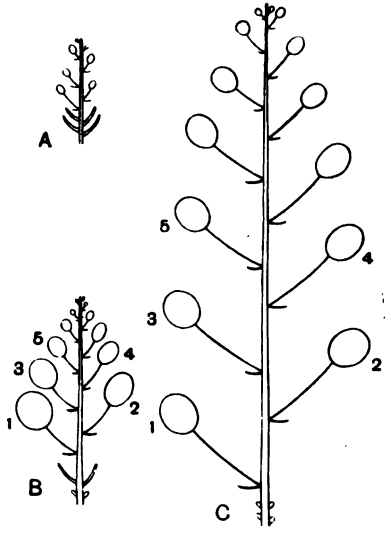


Fig. 1. Stages in the development of a Monopodial Inflorescence (raceme). A, young stage showing seven flower-buds, each in the axil of a bract; there are four bud-scales at the base of the floral axis. B, the same further advanced; the lower flowers, numbered 1—3, nearly mature, and several new buds developed at the apex of the elongating axis. C, the raceme almost completed: the bud-scales fallen below. It will be seen that there is only one primary axis, which continues to develope new flowers near its apex in acropetal succession.

As this process developes, the successive lateral segments—each ending in a flower—may straighten themselves out more and more (Fig. 2, B), until the appearance of a common axis bearing flowers and bracts is produced. The straightening out of the successive segments may go so far as to produce the impression of a straight

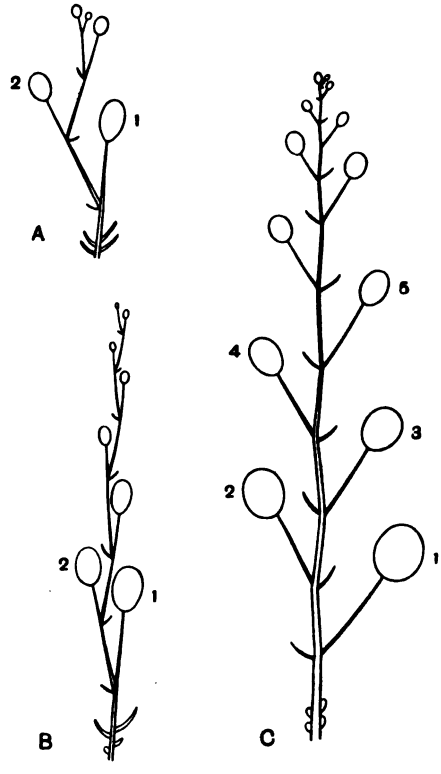


Fig. 2. Stages in the development of a Sympodial Inflorescence (cyme) with one false axis or monochasium. A, young stage shortly after emergence from the bud, the scales of which are visible below: the primary axis ends in a flower (1), and then gives rise to a lateral axis in the axil of a bract to the left; this lateral axis ends in the flower (2) and repeats the process on its right, and so on alternately. B, the several axes, of which more have been formed, are straightening out; until, in C, the process has gone so far that little more than the position of the bracts remains to show that the whole series of successive axes is not a single continuous axis. In reality it is a false axis (monochasium) built up sympodially.

common axis, or peduncle, on which flowers are borne laterally, each with a bract at its base; and so arranged that the oldest flower is below, and each flower above younger and younger until we reach the apex (Fig. 2, C).

Here, it is clear, we have an inflorescence which is raceme-like in form; but, as is equally evident, it is not a true raceme with monopodial structure and acropetal development, but is built up of successive segments, each of which—in spite of the straightening out—is a lateral structure.

An axis of this compound nature is termed a *Sympodium*, and in this particular case forms a *Monochasium* or *Pseudaxis*—i.e. a false axis—terms used to denote the fact that it is made up of segments of different orders, and not of the nodes and internodes of a true, continuous mother-axis with continued onward growth of the apex.

Moreover, such a *Sympodium* cannot properly be described as acropetal in development, since No. 1 in Fig. 2 is really the terminal flower of the first axis, No. 2 of the second axis, and so on.

For a similar reason the growth cannot be properly termed indefinite—even in the relative sense used above—for the growth of the first axis (Fig. 2, A) is rapidly terminated by the flower 1; that of the second by the flower 2, and so on; whence such an inflorescence is termed *definite*.

Further, since this inflorescence is not monopodial, but sympodial in structure, is not acropetal in development, and is not indefinite, but definite in growth, it would be illogical to call it racemose in the sense defined above. Racemoid in form it is, to a degree so deceptive that we must look for some signs by which such an inflorescence may be distinguished from a true raceme.

In this case the position of the bracts at the base of

each of the pedicels on the peduncle at once serves our purpose.

In the true raceme (Fig. 1) each bract subtends the pedicel in its axil, on the same side of the peduncle as is the flower; in the inflorescence just described (Fig. 2) the bract is on the opposite side of the peduncle from the next nearest flower and pedicel, showing that the successive segments of the sympodial peduncle are in reality axillary, as already described.

These two different kinds of inflorescence are typical of two great classes, as we shall see; the first being the racemose type, the second the cymose type, each of which receives its name from the principal form in its class, the Raceme and the Cyme respectively.

Just as there are many different forms of racemose inflorescences, depending on the relative lengths of the peduncle and pedicels, the prominence of the bracts, and other peculiarities, so we shall meet with various forms of cymose inflorescences, depending on the relative lengths and numbers, and on the arrangement of the segments of the sympodial peduncle, the pedicels, bracts, &c.

Before passing to a description of these, I may point out that racemose inflorescences are usually comparatively easy to recognise, while cymose inflorescences are often very difficult.

The difficulties are owing partly to the fact that the bracts may be absent; partly to the changes which come over the forms of inflorescences as they age; and partly to the complex nature of the branching, or the suppression of some of the branches.

Fundamentally, the determination of the characters of an inflorescence depends on the study of the order of development of the young flowers; but experience in the field soon shows that most of them can be determined by

such signs as the position of the bracts, the relative lengths of the various axes, and the degree of advancement of the flowers in different regions.

There are, however, certain specially difficult cases of mixed inflorescences, in part racemose—i.e. monopodial and acropetal—in part cymose—i.e. sympodial and definite. Such of these as concern the plants here treated will be dealt with in the sequel. The same may also be said of some peculiar forms not readily brought under either head without a special study of the development of the whole inflorescence.

The principal point for the moment, and it is a fundamental one, is the difference between the uniaxial or monopodial, and the multiaxial or sympodial type of inflorescence in the sense referred to above.

A rough illustration of the principal differences between the two types may be furnished by supposing a ball of string, from which we slowly draw out one end: as the string is pulled out a short way, suppose we tie another short piece of string in a knot just below the apex to represent a bract and flower-bud. We then pull the string out a little further, slipping this first knot down as we do so, and tie another knot round beneath the apex, and so on. The final effect will be that of an axis, with the knots developed in acropetal succession, as it were, down its length.

In this way we should produce an approximate model of a monopodium, in so far as the axis is one length of string.

Now suppose we start by pulling the string out a short way and then stop; we then take another piece of string of about equal length, and tie it just beneath the upper end of the first piece—"hanging" it, as it were. Meanwhile suppose a flower-bud to have formed at the end of the strangled piece, representing the head, and a bract to

the Broom, Gooseberry, Pimpernel, some Veronicas, &c., it is customary to refer to the flowers as solitary and axillary; though it will be obvious on comparison that if the bracts were less like the ordinary leaves, we should regard the whole flowering branch as an Inflorescence, and in some of these cases the whole flowering shoot is termed a leafy raceme—e.g. *Veronica hederæfolia.*

Examples of leafy racemes also occur in

Whin	*Erica carnea*
Creeping Azalea	*E. vagans*
St Daboec's Heath	*E. ciliaris.*

The peduncle in Fig. 3, A, forms a single, on-growing

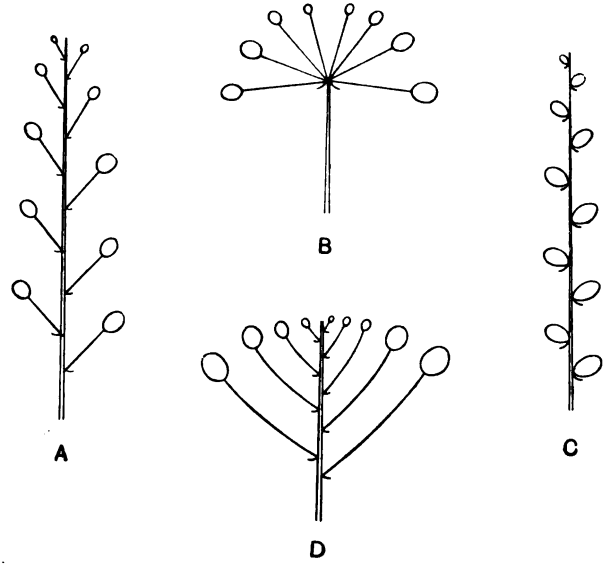


Fig. 3. Simple Racemose Inflorescences. A, a true raceme, the axis not terminated by a flower; B, simple umbel; C, a spike; D, a true corymb.

axis—a monopodium, as already described (Fig. 1); the youngest flower-bud is nearest the still elongating apex, and like the successively older ones is on a short pedicel springing from the axil of a bract. Here we have a typical monopodial inflorescence; and it is agreed that where, as here, an elongated peduncle bears lateral flowers each on its own pedicel, and in acropetal succession, the youngest being at the top and the others older and older as we descend, the inflorescence is indefinite. In the typical case the apex does not end in a flower, but continues to grow forward for some time, indefinitely; but in most cases the process at length ceases by the development of a terminal bud.

Such an indefinite, monopodial inflorescence, in which the pedicels are short and approximately equal, is termed a Raceme, and is characteristic of very many plants, such as the Foxglove, Lily of the Valley, Hyacinth, and Cherry Laurel, where it is erect, and the Black and Red Currants, Barberry, Laburnum, Robinia (Fig. 4), &c., where it is

Fig. 4. Pendent Raceme of Robinia.

pendent. The bracts and bracteoles may be caducous, and are not always developed (e.g. Cruciferæ) and the length of time during which the peduncle actually grows and gives off lateral pedicels varies much—in some Crucifers, for instance, it goes on elongating for several weeks or months.

The principal characters of the Raceme are, then, the elongated peduncle, the flowers on lateral pedicels about equal in length, and their development in acropetal or ascending order. The raceme sometimes terminates at length in a flower—e.g. *Acer* and *Berberis*, whereas the typical raceme of *Prunus Padus*, *P. Laurocerasus*, Red and Black Currants, &c., does not. There is no doubt that in the former case we have transition to the cymose type.

The following trees and shrubs furnish examples of flowers in racemes:

Cherry Laurel	*Loiseleuria*	Gorse
Sycamore	*Menziesia polifolia*	Black Currant
Bird Cherry	*Vaccinium uliginosum*	Bearberry
Portugal Laurel	Barberry	Bell Heather
Petty Whin	Mahonia	*Erica vagans*
Red Currant	Robinia	*E. carnea*
Arbutus Unedo	Cowberry	*E. ciliaris*
Ling	Laburnum	*Rhododendron.*

If we suppose a raceme to have the peduncle shortened, and the pedicels of the lower flowers long, and those of the upper ones shorter and shorter as we ascend, so that all the flowers come to open at a common level or nearly so, the flat or slightly convex bunch of flowers is termed a *Corymb* (Fig. 3, D); e.g. *Prunus Mahaleb*, Pear, Hawthorn, &c. That the true corymb is merely a shortened-up variety of raceme is shown by the fact that a raceme is frequently a corymb when young, and gradually attains

its typical form as the peduncle and upper pedicels lengthen out; e.g. the Stock, Wallflower, &c.

At the same time it should be noticed that the term corymb is used somewhat loosely for any branched inflorescence where the pedicels arise from a common shortened axis, and their branches are so arranged that

Fig. 5. Corymb of Norway Maple.

the outermost are longer than the inner, and thus bring all the flowers up to a common level, or slightly rounded, surface (Fig. 5). The true, typical corymb is, as we have seen, simply a somewhat compressed raceme; but in many cases the corymboid inflorescence is really a Cyme in composition, as we shall see, and should properly be termed a Corymboid Cyme.

True corymbs are rare, but many of our trees and shrubs have corymboid inflorescences not strictly racemose in origin, as will be shown later.

The following afford examples of corymbs:

Pear Norway Maple Apple Maple.

When the shortening of the primary axis is so pronounced that all the pedicels appear to arise from one point, and spread out like the ribs of an umbrella, the inflorescence is an *Umbel* (Fig. 3, B), e.g. Ivy (Fig. 6), Cowslip, species of *Allium*, Umbelliferæ, &c.

The following afford examples of umbellate inflorescences:

Erica Tetralix	Cherry	*Andromeda*
Prunus Avium	Ivy	Umbelliferæ.

The umbel of the Cherry, *Prunus Avium*, &c., is devoid of a terminal flower; whereas in some umbel-like tufts, e.g. Almond, such a flower exists, whence we have again transitions towards the cymose type.

In these cases of racemose inflorescences with a shortened primary axis, and where the flowers on the elongated pedicels are brought to a common level or nearly so, it is clear that the outermost flowers correspond to the lowermost in a raceme, and the order of expansion is from outside to centre, and so it came about that such inflorescences of the racemose type are often termed

centripetal, corresponding to the term acropetal used for elongated inflorescences.

Fig. 6. Umbel of Ivy (D).

This is still more evident in the *Capitulum* (Fig. 7), which is a variety of the racemose type in which not only is the primary axis shortened, but the secondary ones also, so that the flowers come to be sessile and form a sort of little head: in most cases the apex of the peduncle is expanded into a flattened (Sunflower) or dome-like (Dandelion) or conical (*Matricaria*) receptacle on which the flowers are inserted, the youngest being in the centre of the disc or apex of the cone, dome, &c., and the oldest outside (Fig. 7, A).

Both in the umbel and in the capitulum the outer bracts

are also usually crowded round the insertion of the pedicels, or the base and margin of the receptacle, and form an *Involucre*. Examples of capitula are common in herbaceous plants, but very rare in shrubs or trees: they are

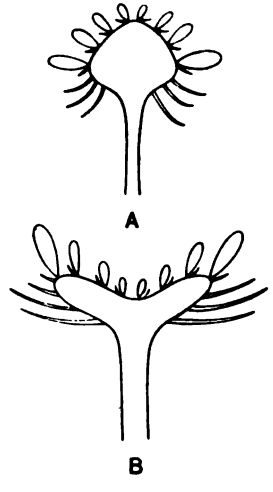


Fig. 7. Capitulum. A, with a conoid receptacle, on which the florets are sessile, each in the axil of its bract, in acropetal order; if the receptacle were somewhat more elongated this capitulum would pass into the spike. B, with an expanded and slightly depressed receptacle, the florets in centripetal order; if somewhat more depressed in the centre, and the margins approximated above, the florets would line a hollow receptacle, as actually occurs in the Fig.

characteristic of Compositæ, Sunflower, Daisy, Thistle, &c., and their relation to the umbel and to the following inflorescence (*Spike*) may be traced in the Teazle, Acacia, Clovers, &c. The extremely dilated inflorescence of *Dorstenia* is essentially of the same nature, as is also the large clavate one of *Artocarpus*, and the hollowed or introverted form of the Fig, all of which inflorescences are

found with numerous transitional forms in the Urticaceæ (Fig. 7, B).

The true capitulum is even rarer than the umbel and corymb in our trees and shrubs, but the Planes afford examples of inflorescences very like capitula.

Returning now to the typical raceme. If we suppose the flowers to become sessile on the peduncle by the suppression of the pedicels, everything else being as in the type, the inflorescence is a *Spike* (Fig. 3, C); e.g. *Plantago*, Mullein, *Verbena officinalis*, and many Orchids, &c., where the spike is erect, while in other cases it may be pendent.

Typical spikes are not uncommon, but on our trees and shrubs the spicate inflorescence is far more apt to occur in one of the modified forms to be referred to shortly, especially the *Catkin*. The best example of the spike among the trees, &c., here concerned, is furnished by the Tamarisk, but the following exhibit inflorescences which are spicate in form, though found to be more complex on dissection, because each bract carries in its axil more than one flower, or something in addition to the flowers:

Chestnut	Alder ♀	Oaks ♀
Birch ♀	Hornbeam ♀	*Empetrum.*

If the spike, erect or pendulous, bears male—denoted by the sign ♂—or female—denoted by the sign ♀—flowers only, with prominent and scaly bracts, it is termed a *Catkin*; e.g. Poplar, Willow, &c. (Fig. 8).

If the axis of the spike is swollen and fleshy, while the base is enveloped in a large sheathing bract (*Spathe*), it is termed a *Spadix*, e.g. *Arum*, *Calla* and other Aroideæ. The apical portion of the spadix is often devoid of flowers and peculiar in shape and hue, and the spathe may be brilliantly coloured (e.g. *Anthurium*) or white (e.g. *Richardia*).

Catkins, or catkin-like spicate inflorescences are found in the following:

Bog Myrtle	Hornbeam ♂	Birch ♂
Poplars	Beech ♂	Hazel ♂
Alder ♂	Willows	Walnut ♂
Oaks ♂.		

Fig. 8. 1, a staminate or male catkin, and 2, a pistillate or female catkin of a Willow.

As we shall see later, there are considerable differences

in detail in the structure of these inflorescences. Those of the Willows and Poplars are the simplest and most typical; but those of the Alder and Birch, for instance, contain more than one flower in the axils of the bracts, and are really catkin-like spikes composed of small groups of flowers on the one axis.

The growing apex of some racemes or spikes developes leaves which bear no flowers in their axils, and goes on elongating long after the flowering—e.g. *Mezereon* (Fig. 70), Sea Buckthorn (Fig. 71), *Melaleuca*, *Callistemon*, *Ananassa*, &c., and something similar occurs in the case of many Conifers, e.g. the staminate inflorescences of the Pines (Fig. 50); but it is evident that these cases link up with those where the presence of flowers in the axils of leaves on foliage-shoots often deters us from calling such shoots spikes, racemes, &c. In *Muscari comosum* the raceme becomes sterile at its summit, by the exhaustion and atrophy of the flowers.

In *Genista tinctoria* the raceme is interrupted, intercalated bracts without pedicels in their axils appearing between the flowers.

The student should notice that in all the *simple* forms so far described three chief points are in question, viz. the shape of the whole inflorescence, the relations of position between the primary and secondary axes, and the relative elongation of these axes.

The shape is of less importance than the relations of position and elongation, and the student should carefully exercise himself in determining various types of inflorescence in view of these points. In the field it is of course impossible to make out the facts of development directly, and recourse has to be had to the relative sizes and positions of the buds, bracts, &c. If in an inflorescence which looks like a raceme, for instance, the pedicels do

not arise from the axils of the bracts but from points opposite to the latter (e.g. species of *Drosera, Sedum, Cynoglossum*), we may be sure that however like a raceme the inflorescence is, its development will prove it to belong to another type altogether—i.e. the cymose type; or, again, if in what looks like a corymb, the *central* flowers open before the outer ones, the inflorescence is not of the racemose type, and requires closer examination.

In a few cases the bracts are not developed—e.g. in Crucifers and many Boragineæ—and then the analysis

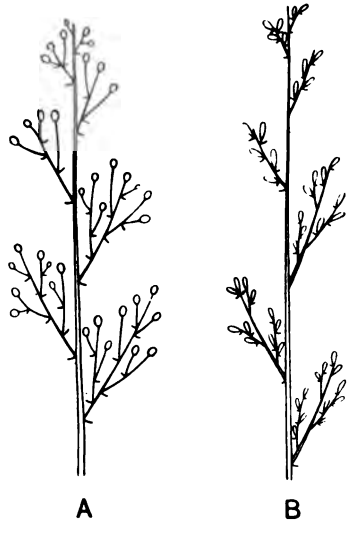


Fig. 9. A, a Panicle or compound raceme; i.e. a Raceme of racemes. B, a Panicle of spikes.

may be difficult until some experience has been gained, and numerous forms compared. With such cases, however, we are not here concerned further, and I only mention

them to illustrate the kinds of difficulties to be expected when the morphological sign-posts, as it were, are lacking.

Any of the above racemose inflorescences may occur branched, instead of simple, i.e. the primary axis bears not single pedicellate flowers, but secondary axes which branch in their turn (Fig. 9). We thus get forms such as the compound raceme—raceme of racemes—or true *Panicle*, e.g. *Yucca*, *Anthericum ramosum*, *Desmodium racemosum*, *Virgilea lutea*. In most Grasses we have compound spikes (spikes of spikelets), e.g. Wheat, Rye, *Lolium*, &c., or loose racemes of spikelets—commonly termed panicles—as in *Bromus*, *Digraphis*, *Milium*, *Holcus*, &c. Compound umbels—i.e. umbels of umbels—are more often met with in the Umbelliferæ than are simple ones; in these cases the partial umbels are termed *Umbellules* and their involucres, when present, *Involucels*—e.g. *Ægopodium*, Carrot, Cow Parsnip, &c.

With regard to these compound inflorescences we may distinguish between homogeneously compound—e.g. a raceme of racemes—and heterogeneously compound forms —e.g. a raceme of spikes.

We shall meet with many cases of mixed compound spicate inflorescences among forest trees, usually as spikes or catkins of small cymose groups. These will be dealt with in detail in the sequel.

CHAPTER IV.

CYMOSE INFLORESCENCES.

Sympodial branching—Analysis—Terminal flower—Monochasium—Dichasium—Polychasium—Corymboid Cyme—Fascicle—Glomerulus—Helicoid Cyme—Scorpioid Cyme—Simple and Compound Cymes—Homogeneous and Heterogeneous Cymes—Mixed Cymes—Thyrsus—Transitions—Reductions—Accessory flower-buds—Concrescence—Displaced bracts—Torsions, &c.—Formal and morphological aspects of Inflorescences.

IT has already been shown that the fundamental character of the cymose inflorescence is the sympodial branching.

This may result in the production of forms so closely imitating all the chief varieties of racemose inflorescence, that the same formal terms—raceme, spike, panicle, corymb, umbel, capitulum, &c.—are often somewhat loosely applied to them by field botanists when simply referring to their shapes.

Yet careful analysis of the order of development and opening of the flowers, the positions of the bracts, and so forth, will in most cases determine whether the inflorescence should be regarded as cymose or not.

In practice, so far as our trees and shrubs are concerned, the numerous cymose inflorescences come under the simpler kinds, and are usually concerned more with the ultimate branches of mixed inflorescences than with the highly complex cymose systems met with in certain groups of plants—e.g. the *Bostryx* (Fig. 12, C) or Helicoid

Cyme, found in *Hemerocallis*, and the *Cincinnus* (Fig. 12, B) or Scorpioid Cyme, of the Borragineæ, which most people would regard as forms of spikes and racemes until closely examined; or the *Drepanium* (Fig. 12, F) or Sickle-shaped Cyme of the Rushes, and the *Rhipidium* (Fig. 12, D) or Fan-shaped Cyme of the Iris, which have no close analogies in our woody plants.

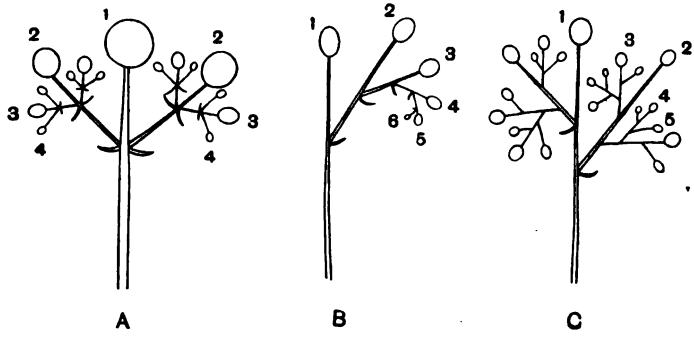


Fig. 10. Types of Cymes. A, a Dichasium built up of successive pairs of opposite branches on the primary axis, each ending in the flower (1, 2, 3, &c.): if three or more branches arise together each time, it becomes a Polychasium or Umbellate Cyme. B, a Drepanium, resulting from the continued suppression of one of the branches, always on the same side, in A. C, a Dichasium built up of successive pairs of alternate branches, one on either side. The numbers give the order of succession.

Passing to the simpler forms of *cymose* or *definite* inflorescence, the first point to notice is that the elongation of the primary axis is rapidly arrested, because it ends in a flower which opens before those on the secondary axes do—simply because it is developed earlier and is therefore older.

The simplest case of all is where the peduncle has only one terminal flower, e g. the Poppy. If from the axils of bracts below this terminal flower, branches should be

borne, each ending in a younger flower and with or without other still younger axillary flowers, we should have a type of inflorescence where the oldest flower is *terminal*, whether it stands at a higher level or not than the successively younger ones.

The Harebell affords a good example. The primary axis ends in a flower, and bears bracts along its length; from the level of insertion of the bract next below another pedicel arises and ends in a younger flower, and a still younger one is borne by a branch from the level of a bract on this, and so on. In this way the advanced inflorescence may present a superficial resemblance to a raceme, as already described on p. 13, but it is obvious that the whole has been built up in a totally different manner, because the bracts stand on the side of the apparent main axis opposite the flowers; we have here, in fact, a pseudaxis (Monochasium) or *Sympodium* of exactly the same character as in the case of the example given in Fig. 2, or of the Lime or Vine branches referred to when dealing with ordinary shoots in Vol. I. pp. 114, 115; and its true nature is betrayed at once by the relative positions of the pedicels and bracts.

Such an inflorescence comes under the general designation of a *Cyme*. Other examples are furnished by Buttercups, Columbines, &c. They may be termed racemose, corymbose, &c., in purely descriptive accounts, where the form only is considered and not the order of development.

Examples of corymboid and umbellate cymes are afforded by the following:

Lime	Cotoneaster	Hawthorn
Apple	Beam	Sorb
Rowan	Service-tree	Elder
Wayfaring Tree	Guelder Rose	Blackberry.

Several important varieties of the cyme occur in plants where the leaves or bracts are opposite, instead of alternate. In the *Dichasium* (Figs. 10, A, and 11) we have the axis ending in a flower (1), the oldest of all; from the

Fig. 11. Dichasium of Spindle Tree.

axil of each of the two opposite bracts just below this flower, springs a secondary pedicel, also ending in a flower (2) and in its turn bearing tertiary pedicels similarly ending in a flower (3), and so on. Examples abound in Caryophyllaceæ, e.g. *Cerastium, Stellaria,* &c.,

also *Erythræa*. In Labiatæ we find a shortened Dichasium in each opposite leaf-axil (*Verticillaster*).

If, instead of two lateral axes, three or more arise from the primary axis, we have the *Polychasium*, a form of inflorescence so like the umbel in configuration that it is often termed an umbellate cyme (Figs. 10 and 13).

When the various laterals do not arise from the same level on the primary axis, but are of such lengths as to bring all the flowers to about equal heights, we have the corymboid cyme, e.g. *Laurustinus*, Cornel, *Hydrangea*, &c.

In other cases we find the secondary axes shortened and the cyme becomes a *Fascicle*, e.g. Sweet William; or the secondary axes may be even done away with, and the flowers sessile in a capitulum-like inflorescence, only distinguishable from the true capitulum by the centrifugal order of opening of the flowers; such a *Glomerulus* occurs in the Box, Nettle, &c.

Examples of condensed dichasial cymes are afforded by

Birch	Alder	Hornbeam
Chestnut	Beech	Oak,

in which the small dichasium in the axil of each scale of the catkin is reduced to three, or two flowers, or even to one only, and its nature can only be discovered by a close examination of the bracts.

Examples of condensed cymes are also seen in

Holly	*Rhamnus*	Elms
Lonicera	Box	Mistletoe,

where the more or less tufted *fascicles* or *glomerules* are shown to be cymose in development.

That cymes of the dichasial type described above only differ in degree from those with an apparently single false axis (Monochasium) can be easily demonstrated.

Suppose the true Dichasium to have one of the two lateral axes suppressed at each branching; we then have a sympodium or false axis (Monochasium) developed.

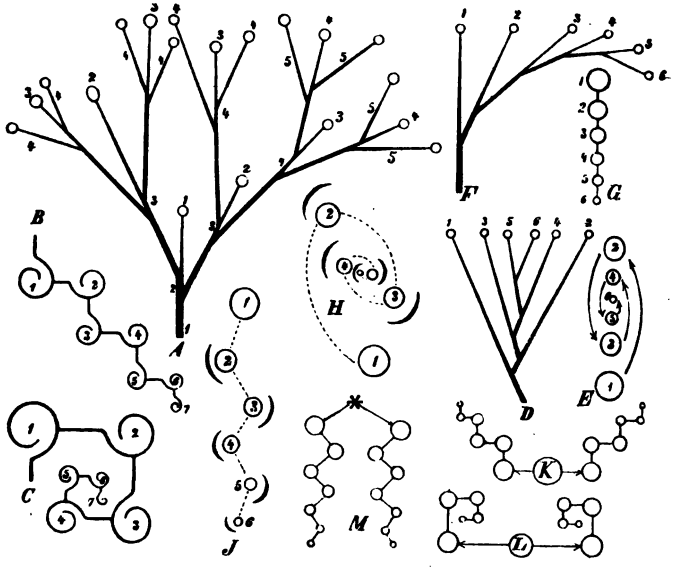


Fig. 12. Cymose Inflorescences of the more complex orders. *A*, a Dichasium, the order of development of the flowers denoted by the numbering. *B*, a Scorpioid cyme, and *C*, a Helicoid cyme, both in plan. *D*, a Rhipidium or fan-shaped cyme, and *E*, the same in plan. *F*, a Drepanium or sickle-shaped cyme, and *G*, the same in plan. *H*, a Bostryx or Helicoid cyme passing into a Rhipidium or fan-shaped cyme, in plan. *J*, a Scorpioid cyme passing into a Drepanium, in plan. *K*, a double Scorpioid cyme, in plan. *L*, a double Bostryx, in plan. *M*, a displaced double Scorpioid cyme, in plan. In all cases the numbering gives the sequence of the flowers (Ei).

If the suppression is always on the same side we have the so-called *Helicoid* type of cyme (Fig. 12, C) as in Boragineæ, if on alternate sides the *Scorpioid* type

(Fig. 12, B) as in Helianthemum, Drosera, &c. Further distinctions are made according as the branches are arranged in one plane or in several planes, but as the terms employed have not all received general acceptance, and since these complex types concern us but little, I pass over further details.

As with racemose, so with cymose inflorescences, we may have them simple or compound, and the latter homogeneous or heterogeneous—for instance Cymes of cymes are common in Caryophyllaceæ and Racemes of cymes in Campanulaceæ. The panicle-like mixed inflorescence of the latter type is frequently termed a *Thyrsus*, but there is considerable difficulty in determining the details in many cases: the Horse-chestnut affords a good example, however.

Examples of cymose panicles are afforded by the following:

Horse-chestnut	Vine	Sumach
Lilac	Privet	Tree of Heaven
Aucuba	Clematis	Virginian Creeper.

Extended research shows that there are very numerous cases where racemose and cymose inflorescences pass into one another, and these transitional forms go to show that, in spite of the fundamental differences existing between the types, practically no sharp line of demarcation exists between the Raceme and the Cyme. For instance, the raceme of the Barberry really ends in a flower which, although it is the first formed and the first to open, usually suffers abortion before the rest begin to open, and since these latter follow the ascending order we are justified in retaining for it the name of Raceme, as we have done on p. 20. In the thyrsoid inflorescence of the Lilac we have a similar but more complex case.

Other cases of mixed and transitional inflorescences occur in the Campanulaceæ, Oleaceæ, Linaceæ, &c.

Examples of mixed inflorescences, which may begin their branching as Racemes, Corymbs, &c., but the ultimate ramifications of which pass over into Dichasia, Polychasia, &c., are afforded by the following:

Rubus Idæus	*Cratægus*
R. fruticosus	Apple
R. Cæsius	Pear
Pyrus Aria	*Rosa Canina*
P. Aucuparia	*R. rubiginosa*
P. torminalis	Ash
P. Sorbus	Horse-chestnut
Privet	Lilac.

Certain special difficulties in the analysis of inflorescences are worth noting, as they can only be solved by comparing allied species or by the study of development. In the Vetches (*Vicia*), for instance, all transitions occur in the various species from typical racemes with numerous flowers (e.g. *V. Cracca*) to short and few-flowered racemes (*V. gracilis*) and axillary pedicels with only two flowers (*V. sativa*) or even one (*V. lutea*), and similar reductions occur in *Ribes*—e.g. *R. rubrum* and *R. nigrum* have racemes, but in *R. Grossularia* these may be reduced to two or even only one flower in the axil. In the same way cymes are reduced to pairs of flowers in *Lonicera*, and other cases occur in Violaceæ, Convolvulaceæ, Malvaceæ, Geraniaceæ, &c. A peculiar case of especial interest to us is met with in the groups of three or two or even one flower in the axils of the catkin-scales in the Alder, Birch, Chestnut, Beech, Oak, &c.

In other cases the inflorescence is complicated by the development of accessory flower-buds, collateral or

superposed, in the axils of bracts, just as accessory leaf-buds occur elsewhere (see Vol. I. p. 37), e.g. *Malva sylvestris.*

In *Yucca gloriosa* the racemes have two collateral flowers in each bract-axil, and superposed flowers occur in *Œnothera rosea, Fuchsia gracilis,* &c. Moreover, one or more of the accessory buds may develope into a leaf-shoot, as in *Clematis recta,* &c.

Some of the most striking peculiarities of inflorescences are due to concrescence between the bracts and the flower-stalks—i.e. their tissues grow up together united into a common mass—and various degrees of complexity may occur here.

One of the simplest cases is that of the Lime, where the general peduncle is united about half-way up the bract of its own axis (Fig. 106). This is carried further in many *epiphyllous* inflorescences — e.g. species of *Helwingia, Polycardia, Phyllonoma, Erythrochiton, Phyllobotryum, Chailletia, Spathicarpa, Spathantheum,* &c., where the flowers appear to spring directly from the surface of the leaf.

These cases must be carefully distinguished from flowers borne in the axils of minute scale-like bracts on flattened axillary shoots (cladodes) as in Butcher's Broom (Fig. 94), a point of the more significance since both forms occur in species of *Asparagus* and *Ruscus.*

It not unfrequently happens that the lamina of the concrescent bract is not developed below, but only where it becomes free, and the peduncle thus appears with a bract somewhere along its length, above its insertion, and shows no sign of being axillary—e.g. *Samolus Valerandi,* &c. These cases of *displaced bracts* are by no means uncommon and give rise to curious difficulties in the analysis of inflorescences, especially in the Solanaceæ,

of which they are characteristic. In Boraginaceæ, Crassulaceæ, *Helianthemum*, *Cuphea*, &c., we find other striking examples of such displacements.

Other causes of complexity of inflorescences, due to torsions, the pressure of neighbouring organs, deflexions, &c., must be passed over here.

Fig. 13. Umbellate Cyme (Polychasium) of Elder.

It will be evident from the foregoing account that there are two principal aspects of an inflorescence; the purely formal one, where any elongated axis bearing unifloral pedicels of about equal length is regarded as a raceme, and any axis bearing lateral flowers on pedicels of graduated lengths, bringing the flowers to a more

or less similar level, is regarded as a corymb, and so on; and the morphological aspect, according to which the mere form is further analysed, by examination of the mode and sequence of branching, the order of opening of the flowers, the position of the bracts, &c., to determine whether it is racemose—indefinite, centripetal, acropetal, monopodial, &c.—or cymose—definite, centrifugal, sympodial, &c.—in development.

For purely descriptive work in the field, the formal aspect often suffices; but it is obvious that the morphological aspect leads to greater accuracy, and it is sometimes of great importance. It is, however, often a difficult task to thoroughly analyse and define cymose inflorescences, and it may be worth while to note that in the cases here concerned, the dichasial type prevails, and may usually be detected at the ultimate ramifications of cymose and mixed inflorescences.

CHAPTER V.

THE FLOWER IN GENERAL.

Dissection of Flower-bud—Resemblance to Leaf-bud—Green floral organs, &c.—Sepals and Petals—Stamens and Carpels—Their leaf-nature—Calyx and Corolla—Andrœcium and Gynœcium—Argument from comparative morphology and development—Modifications and Metamorphosis—The Ideal Flower—Succession of leaf-organs—Colour.

On dissecting a young flower-bud of a Buttercup, Water-lily, Geranium, Barberry, Tulip, Lily or Rhubarb, or that of many other common plants, it is by no means difficult to make out that it consists of parts reminding us of young leaves, springing from an axis, overlapping one another more or less, and the more external of which are curved up over the internal ones, and over the end of the axis which bears them. Moreover, these flower-buds occupy positions similar to those of ordinary leaf-buds, and may often be seen distinctly springing from the axils of common green leaves: the latter, it is true, are apt to be smaller than the ordinary foliage-leaves of the plant, and receive the special name of *Bracts*, or floral leaves.

So far the flower-bud presents essential resemblances to any ordinary leaf-bud, such as was described in Vol. I. pp. 9–22, and if the overlapping organs of the above flowers expanded into *green* structures, instead of acquiring

bright colours or turning white as they so often do, no one would overlook the reality of these resemblances.

But there are certain flowers which do retain the green colour in some or all of their parts; and many others, the leaf-like parts of which are normally not green, occasionally revert to the foliar type, as if practising an old habit which some change in conditions has compelled them to resume.

For instance, the two outermost parts of a Poppy-bud are green, and those of a Mallow or a Strawberry are still more leaf-like, both in form and colour. Again, the innermost parts of the white double-flowering Cherry are obviously of the nature of green leaves, and cases occur where any, or even all, of the parts of the bud are transformed into leaves, as shown in monstrous Pears, Roses, and other flowers. Instances are even cited where the forming flower-bud produces flowers in the axils of the parts.

Nevertheless, it is clear that an opened flower of most kinds of familiar plants does not suggest the above resemblances. Taking a common field Buttercup, for example, the student finds a few greenish organs outside, called *sepals*, which show a slight venation and other resemblances to leaves, and these are followed by the larger bright yellow *petals* which he may not think essentially like leaves in anything but shape, until he sees they also have a delicate network of venation running through the tender tissues. Next come a number of filamentous organs, each with a club-shaped upper end, and these *stamens* by no means suggest leaves to the uninitiated: nevertheless each has a vascular-bundle running up its centre, like a midrib up a narrow leaf, and each is inserted on the axis as a leaf would be, and in its very young stages is indistinguishable from a young leaf. Finally, in

the central region of the flower he finds a number of small, green, hollow *carpels*, each of which, on careful examination with a lens, will be seen to be like a miniature short inflated pea-pod with one pea in it, and, like the pea-pod, suggestive of a folded green leaf.

By choosing suitable examples from a number of different flowers, it is easy to see that some show the leaf-like characters of the *sepals* better than others; others, again, illustrate these features in the *petals*, or the *stamens*, or the *carpels* respectively, and serve as examples.

The sepals, which form the outer covering of the flower, known collectively as the *calyx*, are commonly more leaf-like than the other parts of the flower, as is especially evident in many Roses (Fig. 14).

The petals form the more internal of the two sets of organs covering the ordinary flower, and are known collectively as the *corolla*: their essentially leaf-like nature is shown in monstrous flowers such as occasionally occur in Clover, Roses, &c.

The stamens are termed, collectively, the *andrœcium*, and constitute the third set of organs in the typical flower. Their essentially leaf-like characters come out on comparing the gradual transition from petals to stamens in Water-lilies, and on examination of the male cone of a Pine, as well as in certain monstrosities where they revert to green leaves. In ordinary "double" flowers, also, it is a common event to find stamens reverting to the petaloid condition, while the same phenomenon is normal in some plants—e.g. *Scitamineæ*.

The carpels, collectively termed the pistil or *gynœcium*, often show sufficient evidence of their leaf-like characters to suggest the homology, as in the female flowers (cones) of the Pines, in Peas, Beans and other Leguminosæ, in the Double Cherry, in Mignonette, Sterculias, &c.

The student must bear in mind, however, that suggestive as the above illustrations are of the leaf-nature of

Fig. 14. Inflorescence of a Rose developed from the flowering bud, and showing transitions of stipular bud-scales n^1, n^2, &c., to foliage-leaves l^1, l^2, &c., each with its large adnate stipules b. In the floral region these pass to bracts h^1, h^2, &c.; and, finally, we come to the foliaceous sepals (E and P).

the floral parts, they by no means suffice by themselves to prove that the flower is merely a modified or altered leaf-shoot. The proof of this depends on the cumulative

evidence obtained by comparing the spore-bearing organs of a very large number of plants, both with and without flowers, and, still more, the development of the parts referred to, which are found to arise on the axis just as do leaves, and in fact to be indistinguishable from leaves in their earliest stages in position, mode of growth, and internal structure. These matters can only become clear after more knowledge, but it seems advisable to give this preliminary sketch of the grounds for asserting that the flower is essentially a shoot, or branch, the parts of which have become modified for special purposes connected with reproductive processes; and that these modified parts are, as regards origin and mode of development, the same things as leaves.

The beginner must also be on his guard against false assumptions regarding the words "modified" or "metamorphosed" as used in the preceding sketch. The statement that a stamen is a modified or metamorphosed leaf, is in the same category as the statement that a tendril is a modified leaf, or branch, as the case may be; and means, not that the individual organ in any given phase in the history of the individual plant was ever actually a leaf, and then changed; but that according to the relations of position, order of development, and fundamental structure, it is produced as the representative of a leaf, and that far back in the distant past, the forces then at work on such shoots would have induced the development of unmistakable leaves where we now find these organs. Indeed such a reversion to the ancestral type is by no means uncommon to-day, and every gardener knows how promising flower-buds may "change their minds" as it were and become foliage shoots after all.

Sufficient has now been said to justify the treatment of the flower, and its parts, as portions of the shoot-

system; and, indeed, there are shoots which consist only of a flower or a cluster of flowers.

In pursuance of this idea of the shoot-nature of the flower, we may consider for a moment some notions, the rudiments of which have been entertained in years gone by, by observers and thinkers who were struck with the above suggestive resemblances of the parts of the flower to leaves, but who had to struggle with their concepts insufficiently provided with a knowledge of development and with what goes on in lower plants.

It may be suggested that an ideal plant would show, proceeding from the base of the shoot upwards, some such changes as the following, occurring on the axis.

First we have the *Cotyledons*, then the *Scale-leaves* and *Foliage-leaves* which even on an ordinary plant exhibit many individual differences of form, size, &c., in the lower, middle and upper parts of the shoot; then come the *Bracts* and *Floral leaves*, and stress may be laid on the evident tendency of the bracts to depart more and more from the type of the foliage-leaves, and often to approach the parts of the flower in character, and of the latter to diverge still more from the leaf type as we pass from calyx to stamens.

In spite of many mistakes, and not a few absurdities, perpetrated in this connection, the notion of an ideal shoot is a useful one, and the facts referred to may be compared with what is shown in Fig. 14; and if we suppose the internodes between the different series of floral leaves to be shortened, and these leaves themselves to be definitely grouped into whorls or close spirals, we obtain a fair idea of the flower as presented by the vast majority of the higher plants.

The principal reason for the popular impression that the flower is something quite different from other parts of

the plant is owing to the prevalence of brilliant colours and strange forms in, particularly, the corolla; but the student must disabuse his mind at the outset of this prejudice. The colour of a flower is, apart from its special meaning as an adaptation for attracting insects and other animals to visit it, one of the least important facts about it, and if all flowers were green many of the initial difficulties in understanding their nature would not appear.

As already stated the chief evidence for the shoot-nature of the flower is that of development: the following sketch of an enormous subject may suffice to show how this is so.

CHAPTER VI.

DEVELOPMENT OF THE FLOWER.

Growing point and lateral appendages—Cessation of apical growth—Crowding of parts and non-development of internodes—Concrescence of parts—Reductions of parts—Changes in order of succession — Development of Buttercup — Of *Heliopsis* — Of Rose, &c.

THE very fact that we speak of the young state of a flower as a "bud" indicates that resemblances have been observed between it and other buds, and these resemblances are real. For if we cut and examine a vertical median section through a young flower-bud such as a Buttercup, it is easy to see that all the parts spring as lateral outgrowths from a dome-like growing point. If very young stages are chosen, properly prepared, and examined under the microscope, it will be found that the generalisations already made as to the behaviour of a growing point in giving off lateral growing points (Vol. I. p. 11) apply also to the flower—that is to say, the terminal dome of embryonic tissue puts out lateral domes which may branch in their turn and so extend its surface, and these lateral outgrowths become sepals, petals, stamens, &c., instead of ordinary leaves, branches, &c.

In the flower, however, it is very rare to find matters so simple as in an ordinary bud, and this is due to

several events, among which the following are the more important.

The principal dome of the flower almost always ceases to grow at a relatively early date, and we therefore find it eventually either sunk down among, or below the bases of its lateral outgrowths; or we find that it has undergone even more profound alterations—e.g. the apex may be bodily converted into some special organ.

The lateral outgrowths themselves are so crowded together on the restricted area of the non-enlarging dome, that their positions are perforce altered as compared with those of ordinary leaves, &c., of the shoot; and, as a rule, no internodes are developed.

The young outgrowths are frequently forced into such close lateral contact from the beginning, that their growing bases become fused or concrescent: in other words, they grow together and come off as a whole, rising up from the floral axis as a common rim or ring of tissue which carries up the hump-like incepts of the lateral organs at first originated separately. This makes the lateral organs look as if they had fused or stuck together in their development.

Another consequence of the crowded position of the young organs is that some of them may be starved or crowded out during development, owing to their not being able to hold their own in the struggle for existence with the others, and thus reductions in their numbers are brought about as the flower matures. These reductions or abortions of parts are ruled by the laws of natural selection, and the causes which induce them are complex; but the process utilised is that mentioned, viz.:—the parts begin to develope, but do not reach maturity, the flower having become adapted to do without these particular organs.

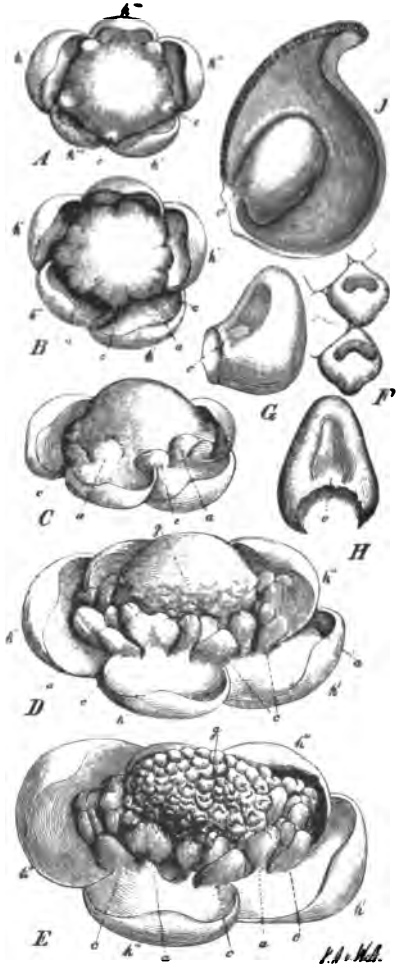


Fig. 15. Development of the hypogynous flower of a Ranunculus. *A*, a very young stage seen from above; the five sepals *k'*—*k''''* are already developed in the order of the numbering, and the five petals *c*, alternating with them, appear as humps on the flanks of the broad apical dome.

B, slightly older stage showing the inception of the first five stamens *a*, somewhat higher up on the dome and alternating with the petals; better seen in *C*, the same stage viewed laterally. *D*, an older stage, from the side, showing the development of more stamens *a*, in acropetal succession, followed by the youngest incepts of carpels *g*, still higher up the flanks of the dome. *E*, still more advanced stage; the carpels *g* are now formed in acropetal succession all over the dome, and the stamens *a*, petals *c*, and sepals *k*, are approaching completion. *F*, carpels from the last figure, seen from above and more highly magnified, showing the infolding of the margins. *G*, the same from the side, and *H* from above, still more advanced and enlarged; the single ovule *o* is arising from the antero-basal placenta, and the margins are closing in over it. *J*, a mature carpel in longitudinal section, showing the ovule in position (P).

In some flowers, moreover, the order of succession of the various parts becomes altered from what we should expect it to be.

After these preliminary matters, we may now examine a few cases in illustration of these and other peculiarities of the development of the flower.

In the figure on p. 50 (Fig. 15) *A* shows the highly-magnified apex of a young Buttercup viewed from above. We see an apical dome of embryonic tissue with 10 lateral protuberances, of which *k'* is the oldest and lowest of what will be the sepals, while *k''*—*k''''* are next in order of succession. Then follow the still smaller and younger petals *c*, still in the condition of mere incepts.

In the next stage, Fig. 14, *B* and *C*, we find the stamens arising as minute lateral outgrowths (*a*) somewhat higher up the still growing central dome; and later on (Figs. *D* and *E*) more and more lateral outgrowths are produced to form the remainder of the stamens (*a*) and the carpels (*g*).

In contrast to this example, where the floral organs arise in their natural sequence on the sides of the dome, we may examine the development of *Heliopsis*, one of the Compositæ.

Here we should find a series of five humps, arising in a ring round the apex, and rapidly overtopping the depressed apex of the dome: these five humps are the young petals conjoined into a common corolla. Just

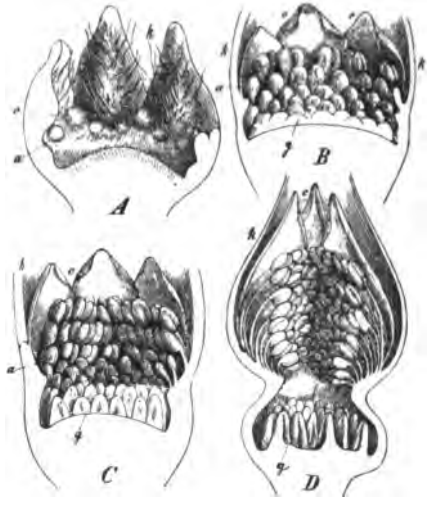


Fig. 16. Development of the perigynous flower of a Rose. *A*, the sepals *k* are in an advanced stage and are being carried up on the calyx-tube; on the inner margins of the latter are appearing the young petals *c* and the first series of stamens *a*, but the convex floral axis (true apex of the flower) is still devoid of carpels. *B*, all parts further advanced, and the young carpels *g* are developing. *C*, somewhat older stage, showing the inward arching of the stamens *a* and petals *c* over the carpels *g*. *D*, flower nearly complete, but still in bud; the up-growth of the rim of the calyx-tube, about the line *a* in previous figures, is now clearly raised above the nearly complete carpels *g*, and carries with it the insertions of the stamens *a*, petals *c* and sepals *k*, but it does not close over above (P).

inside and alternating with them there follow five smaller humps, which will be the five stamens. These two whorls of protuberances grow up together around the rest of the

flower in such a way that, *first*, all the five petal-protuberances are raised as mere pimples by the common growth of their bases as a closed ring, and, *secondly*, the stamens grow up inserted on the inside wall of this tube.

Next we find another wall-like ring or rim arising inside the ring of stamens, and this gradually roofs in the depressed apex of the flower, on which a single ovule now originates.

Reference to the figures of the Apple (Fig. 27), Pear (Fig. 131), *Pyrus Aria* (Fig. 133), Gooseberry (Fig. 135) and other epigynous flowers will help to explain how it is this apex becomes relatively more and more sunk. Not only is there growth upwards of the various protuberances to form the corolla, stamens and carpels, but the common basal portions of all these grow up together as a common ring elevating the apparent origin of all these parts to a level considerably above the original apex of the flower, which they then roof over and enclose as in a box.

Another noteworthy point in this Composite flower is the suppression of the calyx, which does not advance beyond the condition of a mere rim: in allied plants, however, e.g. the Sunflower, five slender sepals arise at this ring, *after* the corolla, stamens and carpels, and are thus deferred in development.

In the case of many Roses and their allies, the sinking of the apex is even more obvious, because several distinct carpels are developed on the floral bed, and the rising up all round of the circumvallate ring of tissue (calyx-tube) which carries up the developing sepals, petals and stamens, is very characteristic. This is well shown in the various stages described in Fig. 16.

In many such plants, indeed, the wall of the calyx-

tube thus developed remains at about the relative level shown in Fig. 15, C, and thus the sepals, petals and stamens are apparently inserted on the rim, or within the margin of a saucer-like or cup-like investment of the gynœcium, and are arranged round it. This is the so-called *perigynous* condition, of which more will be said in the next chapter.

CHAPTER VII.

THE FLOWER IN GENERAL (*continued*).

Receptacle or Torus—Floral whorls—Acyclic, Cyclic and Hemicyclic flowers—Internodes—Dilated and Hollow Receptacle—Flowers with free parts—Hypogyny—Perigyny—Epigyny—Cohesion and Adhesion of parts—Polysepalous and Gamosepalous Calyx—Polypetalous and Gamopetalous Corolla—Other terms—Branching of Stamens, &c.—Apocarpous and Syncarpous Pistil—Ovary.

It will be evident that in the further study of the flower, it is important to observe the relations of the various floral parts to the axis around the summit of which they are inserted (Fig. 15, A): this axis in the flower is termed the *Receptacle*, or *Torus*—i.e. the bed of the flower, on which the parts are inserted.

In the simplest cases the receptacle is, as we have seen, a more or less conical or dome-shaped projection of the axis, around which the parts are spirally inserted, as ordinary leaves often are; but this simple arrangement is very rarely completely carried out in any existing *perfect* flower—i.e. one having all the floral parts—though it is met with in a few Ranunculaceæ (Buttercups and their allies) and some Magnolias, the type being almost perfectly represented by such a flower as that of the Indian *Michelia fuscata*, where we pass gradually by an ascending spiral line from the insertion of the outermost sepal,

through that of the next one, on through the insertions of the six petals, the numerous stamens, and the spirally arranged carpels, right to the apex of the shoot. The terminal flower of *Berberis* is also spiral in the arrangements of its parts, though the turns are so close that it appears whorled (Fig. 17).

Fig. 17. Terminal flower of a Barberry, seen from above.

Even here, however, we notice the initiation of one of the most important phenomena in the evolution of the flower; namely, that the insertions of the sepals and petals are so nearly at the same level that the spiral nature of the line joining them is only detected by close observation. In most flowers, we shall find that the organs of like kind *are* inserted at the same level, in cycles or *whorls* around the axis, due to the shortening or suppression of the internodes: these cases are exactly comparable to the cases where foliage-leaves come to be inserted in whorls instead of in spirals, and obviously the whole subject of arrangement of these floral leaves is one of Phyllotaxy.

More or less completely spiral arrangements of the various floral organs are met with in the flowers (cones) of Pines, Firs, &c., and in a few groups of exotic plants, *Calycanthaceæ*.

It is commoner even in ordinary flowers of such groups as those referred to, however, to find that the sepals and petals are in whorls, and show no spiral arrangement, whereas the stamens and carpels are distinctly inserted along an ascending spiral.

Commoner by far, however, is the arrangement of all the organs in cycles or whorls, and the flower ceases to show any traces of its spiral structure. This is due, in

the first place, to the progressive shortening of the floral axis and internodes: the whole structure is, so to speak, longitudinally condensed.

It is the custom to speak of flowers as *acyclic* when their parts are all spirally arranged, and as *cyclic* where they are in distinct whorls: those cases where the stamens and carpels are spirally arranged, but the remaining parts are in whorls, are termed *hemicyclic*. From what has been said it will be understood that acyclic flowers are the rarest, and that hemicyclic flowers are not common, both being confined to a few existing groups only: the vast majority of flowers are cyclic. No doubt this is due to the gradual extermination of the more primitive spiral arrangement as the cyclic flowers adapted themselves more and more perfectly to the necessities of their environment and functions.

This condensation of the floral axis has taken place in very different degrees in various flowers, moreover, for although the rule is that the insertion of the floral parts are so crowded—condensed as it were—that no internodes can be discerned, distinct and even long internodes are in some rare cases observable in the flower, quite apart from those common beneath it: the latter, for instance, occur between the bracts and the flower in *Anemone*, Herb-Paris, &c. Such internodes in the floral region are also to be seen in *Lychnis viscaria* between the calyx and corolla; in *Gynandropsis pentaphylla* between the corolla and androecium, and again between the androecium and gynœcium; in Passion-flowers and in some *Sterculiaceæ* between the corolla and androecium; while in the North American Crucifers *Warea* and *Stanleya* and some allied plants the gynœcium is always separated by a long stalk-like internode from the androecium.

Nevertheless these cases are exceptional, and the rule is that the floral axis is shortened up, and provides room for the insertion of the organs by growth in some other direction than apical elongation. It is owing to this that we find the receptacle in most flowers swollen, or dilated, or even hollowed in some way: e.g. in the Buttercup, Potentilla and Rose respectively. This vertical condensation, or dilation, of the floral axis, by the early cessation of apical growth, is one of the first principles to be apprehended in the study of the flower.

Perhaps the next principle in order of importance is a direct consequence of the crowding of the young organs, owing to the paucity of room at their insertions in their incipient condition.

In the typically spiral (acyclic) and hemicyclic flowers mentioned above, all the parts, carpels, stamens, petals and sepals, are inserted separately and *free* from one another, and from neighbouring organs, on the floral axis or receptacle; and we notice that the petals and stamens especially are distinctly inserted separately on the true floral axis, and on a level below that of the insertion of the carpels—e.g. the Buttercup, Magnolia, Poppy, Barberry, Wallflower, Catchfly, Geranium, &c. (Fig. 17). In such flowers, where the stamens and petals are distinctly inserted beneath the gynœcium, on the floral axis, the latter are said to be *hypogynous*; and it is of great importance for the student to clearly understand the significance of this term in the organography of the flower, owing to its practical application in the study of systematic botany in the field.

Hypogyny means, then, in its complete sense, that room exists for each stamen and petal, and even sepal, to be separately inserted in the floral axis in serial order, from above downwards, and all taking origin beneath the pistil.

In a large number of other cases, however, as in the Strawberry, Cherry, Potentilla, Willow-herb, many Saxifrages, &c., the stamens and petals cannot be traced to any

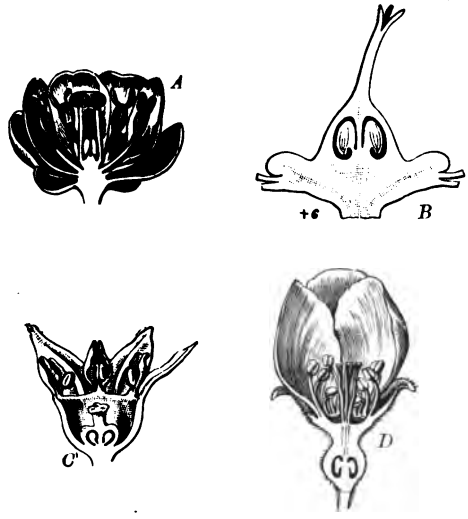


Fig. 18. Vertical sections of hypogynous, perigynous and epigynous flowers. *A*, Barberry, showing the hypogynous stamens, petals and sepals, all free and separately inserted on the floral receptacle beneath the ovary. *B*, Spindle Tree, showing the perigynous insertion of the stamens and petals on the base of the calyx outside the disc, and thus carried away from the floral axis proper. *C*, Rhamnus, showing perigyny even more pronounced; the stamens and petals are carried up on the throat of a cup-like calyx-tube. *D*, Pear, showing the epigynous stamens, petals and sepals, the insertions of which are not only carried up to a level above that of the ovary, but the calyx-tube closes over and roofs in the latter (Wo and E and P).

distinct and separate insertions on the receptacle itself below the gynœcium: they are inserted in a circle, or circles, on the rim of a sort of saucer-like or cup-shaped expansion, which is due to lateral up-growth of the

margins of the more or less flattened or depressed receptacle, carrying up with it the insertions of the petals and stamens (Fig. 17, *B* and *C*). In order to denote the fact that the apparent origin—the insertion—of the latter organs is thus brought into a circle *around* the gynœcium, this state of affairs is termed *perigynous*. The distinction between the hypogynous and perigynous insertion of the stamens and petals can best be understood by comparing the Buttercup with the superficially similar yellow flower of the Potentilla, the former hypogynous, the latter perigynous. See also Figs. 15 and 16.

If the student examines such flowers as those of the Ivy, Gooseberry, Fuchsia, *Epilobium*, Celery, Cow Parsnip, &c., he will find that the insertion of the stamens and petals has been carried up still further than in most perigynous flowers, and on comparing such flowers as the Dog Rose, Apple, Pear and some Saxifrages with these and the preceding flowers, a glimpse may be obtained of the causes at work in bringing this about, and the various stages in progress: the principal of these has been the further extension of such an up-growth as that already described right over the top of the gynœcium, until the latter is entirely covered in above, and the stamens and petals stand off from *above* it. In this case the latter organs are said to be *epigynous*, and here again it is of importance that the significance of this condition be appreciated in order to understand the nature of the flower (Fig. 18, *D*).

Although there are many details in this connection which only become clear when the student has familiarised himself with the phenomena of the development and growth of the flower in its young state, it should at least be now intelligible that while *hypogyny* is the more primitive condition, *epigyny* is the most advanced state

of this gradual sinking or pulling in, as it were, of the gynœcium, as the flower becomes more condensed from above downwards; while the various stages of *perigyny* must be looked upon as intermediate conditions between the two. But the early arrest of onward growth in the central part of the true apex of the flower, which leads to this condensation, brings other changes in its train, some of which we will now examine.

One of the principal of these is that the crowded incipient organs—sepals, petals, stamens and carpels—have no longer room to grow out as separate appendages or outgrowths, each with its own distinct insertion; and so, although each begins to develope as a minute organ on its own account, it continues its growth so closely united with some neighbouring organ, of like or different kind, that the tissues of the two are perfectly continuous at the base, and form a sort of whole, where they pass into the axis of the flower. These unions of the parts of the flower are extremely common, and are often somewhat loosely spoken of as if the parts referred to had been joined or stuck together: this, of course, is not the case, since they have never been developed as independent and separate organs, but have merely grown up in unison.

It is agreed that when this coalescence or union of organs concerns those of like kind it shall be termed *Cohesion*, but where it concerns organs of different value it is called *Adhesion*: thus, stamens cohere with stamens, but adhere with petals, sepals, &c.

Cohesion is very common, as is to be expected from the crowded positions of organs arranged in whorls on a shortened axis, and it occurs in all regions of the flower, reminding us of the similarly frequent cohesions of opposite or whorled leaves in other parts of the shoot.

In the flowers of the Bladder Campion, Corn-cockle,

Red and White Lychnis, Pea, Primrose, &c., we have excellent examples of coherent sepals; and a calyx thus composed of inseparate sepals is usually termed *gamosepalous* in Systematic Botany (Figs. 19 and 20). In contrast to these gamosepalous calices, the student may

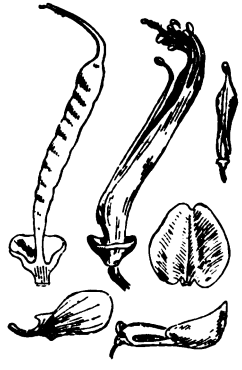


Fig. 19. Parts of the flower of a Robinia, showing the gamosepalous calyx at the base of the two upper left-hand figures; the corolla is polypetalous, and the stamens are diadelphous.

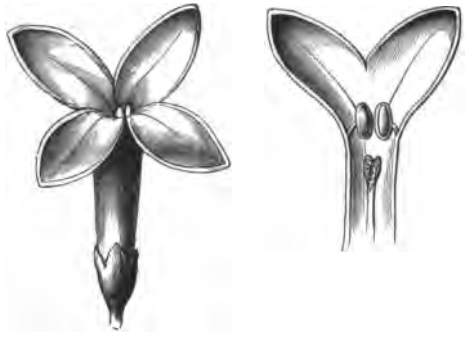


Fig. 20. Flower of Lilac, an example of a gamopetalous corolla with gamopetalous calyx; the stamens are epipetalous.

examine the calyx of the common field Buttercup, Poppy, Wallflower, Stock, Geranium and Wood Sorrel, &c., where the sepals are distinct and separately inserted on the floral axis: such a calyx, of perfectly free sepals, is termed *polysepalous.*

In like manner the petals are coherent in Heather, Rhododendron, Campanula, Primrose, Convolvulus, Foxglove, Deadnettle, &c., and the corolla comes off as one piece, and is termed *gamopetalous* (Fig. 20); whereas the free petals in Buttercups, Wallflower, Poppy, Waterlily, Flax, Geranium, &c., constitute a *polypetalous* corolla in each case.

Undoubtedly the words gamo-petalous and poly-petalous (and -sepalous) are not free from objection if we demand that classical words adopted for scientific terminology should convey in their derived etymological meanings the ideas they are employed to name; but we need not admit this, and may contend that it is sufficient to give the selected word the new meaning it is intended to convey, and simply use it consistently. A great deal of energy seems uselessly expended in inventing new terms on the implied assumption that a Greek or Latin word should carry the translation of the new idea in its etymology, as nearly as possible: obviously it cannot be an exact translation, if only because the Greeks and Romans were not familiar with the new idea, and therefore had no name for it. The terms *Monopetalous, Gamopetalous, Sympetalous,* &c., used in various modern textbooks, all mean the same in Botany, though the etymology is very different in each case; and the same applies to *Choripetalous, Dialypetalous, Apopetalous* and *Eleutheropetalous,* all of which mean the same as *Polypetalous* in Botany, different as their etymological significations are. It is really of little importance which word is used

so long as it is consistently employed throughout with the new meaning science gives it, and the argument to the contrary involves the vicious assumption that science is to be approached through classics. Words like Ohm, Boycott, and so on, are witnesses against this. I shall accordingly adopt the older words Gamo- and Polypetalous, &c.

No doubt ease of pronunciation often decides which of two words persists in the end—e.g. why *eleutheropetalous* has not displaced the etymologically faulty term *polypetalous*, or *sympetalous* the slightly easier word *gamopetalous*.

Cohesion in the androecium, in the above sense of the word cohesion, is not so common as in other whorls, but it occurs in Peas, Beans, Robinia, and other Leguminosæ (Fig. 19), the White Briony, Vegetable Marrow and other Cucurbitaceæ, and in Meliaceæ, *Citrus*, *Oxalis*, Malvaceæ, Lysimachia, &c., where the stamens cohere more or less completely below during development.

In some cases the anthers only are coherent, as in the Sunflower and other Compositæ, *Lobelia*, &c.: they are slightly so also in Violets and in Solanum, but the union is not very complete.

It may be noted here that many cases occur where the stamens are found in bundles, and are regarded as coherent, but are really not so at all: development proves that the groups are formed by the *branching* of one or more stamens during early growth. In the field, for the practical purposes of Systematic Botany it is frequently impossible to distinguish between truly coherent and branched stamens, and it is the custom to ignore the distinction of origin, and simply regard all bundles or groups of stamens coherent. In reality, however, the distinction is of theoretical importance.

In the vast majority of flowers, cohesion of the carpels plays an extremely important part in the development of the gynœcium.

In comparatively few cases, especially such as those of the acyclic and hemicyclic flowers of Magnolia, Buttercups (Fig. 15), Barberry (Fig. 17), and their allies, those of the Potentillas, and in a few Monocotyledons such as Water Plantain, Flowering Rush, Arrow-head, &c., the gynœcium consists of a single carpel, or of a number of separately inserted carpels, which are completely free from one another and from any other organs. In such cases the gynœcium, or *Pistil* as it is often termed, is said to be *apocarpous.*

In by far the greater number of cases, however, the crowding of the incipient carpels into a single circle, or whorl, on the shortened axis, brings it about that they

Fig. 21. Syncarpous ovaries in part cut vertically. *D*, *Ailanthus*, the ovary is composed of three carpels, that to the left in section; the style is cut off short, as are also the stamens at the base of the hypogynous disc. *E*, Spindle Tree; the ovary is composed of four carpels, one of which, to the right, is in section (E and P).

cohere at their sides or margins during development; so that a sort of box, called an *Ovary*, is formed by them collectively.

In all these cases where the pistil or gynœcium

is thus composed of coherent carpels, it is described as a *syncarpous* ovary (Fig. 21).

To illustrate this, it is permissible to employ an analogy which, while not strictly true in point of fact as regards the mode of development, is sufficiently so for the purpose, provided the student does not push it farther than the case demands. If we suppose the carpel to be a folded leaf (and it is homologous with such an organ), then a pea-pod consists of one such leaf, the margins of which are conjoined, and bear the ovules—the young peas or the incipient seeds: the opposite edge of the pod corresponds to the midrib of the leaf, and the inside surface of the pod corresponds to the upper side of the leaf, supposing it expanded.

Now let us imagine two carpels, like pea-pods, to arise in the centre of the flower, so placed that their pea-bearing margins face the centre of the flower and cohere, not margin to margin of the *same* pea-pod, but the margin of the one pod to the margin on the same side of the opposite pod: this would give a larger pod-like box, but composed of *two* coherent carpels, instead of one. Obviously the syncarpous ovary may be composed similarly of three, four, or more such coherent carpels (Fig. 21).

The above illustrative cases are realised in Willows and Poplars, *Corydalis*, *Eschscholtzia*, *Glaucium*, *Capparis*, Saxifrages, *Gentians*, where we find two carpels coherent; in Violets, Reseda, and *Juncus*, some Ochnaceæ, Helianthemum, there are three; in *Parnassia* and some Poppies there are four; in *Cistus*, five, and in many Poppies numerous carpels occur. Here, again, cases are known of the nature of branching, but they concern us very little or not at all.

CHAPTER VIII.

FLORAL ENVELOPES—THE CALYX.

Dichlamydeous Flower — Achlamydeous and Monochlamydeous Apetalous Flowers—Perianth or Perigone—Homo- and Heterochlamydeous Perianth—Examples of achlamydeous, &c., flowers —Polypetalous and -sepalous, &c., flowers—Gamopetaly, &c.— The Calyx—Sepals—Limb and Claw—Obsolete Calyx—Texture of Sepals—Gamosepalous Calyx—Tube, Limb, and Throat— Shapes of Calyx—Regular, Actinomorphic, and Zygomorphic Calyx—Stipular outgrowths—Epicalyx and Calyculus—Persistent, deciduous and caducous Sepals—Marcescent and accrescent Calyx—Pappus—Appendages.

THE Calyx and Corolla of an ordinary flower are often termed the floral envelopes, and the collective term is useful because the two are not always distinguishable even when present. When both floral envelopes are present the flower is *dichlamydeous.*

In many cases, however, the flower has no calyx or corolla, properly speaking, and is *achlamydeous*, e.g. *Piper*, *Salix*, *Populus*, *Myrica.*

In an ordinary Willow, for instance, each of the bracts of the catkin bears in its axil a flower consisting of two stamens, or of an ovary, only, and quite devoid of anything we can call calyx or corolla. Similarly, the flowers of the conifers are *achlamydeous*, as are also those of many Aroideæ, Grasses, &c.

Truly *achlamydeous* flowers are much rarer than *monochlamydeous* flowers, however. In these latter either the calyx or the corolla is wanting, and far more commonly the corolla. Examples are found in *Clematis*, Mezereon, in the common Elm, Nettle, &c., and in the Natural Orders Caryophyllaceæ, Chenopodiaceæ and Polygonaceæ, &c.

Owing to technical difficulties in determining by direct observation in the field whether a flower is monochlamydeous or achlamydeous—e.g. Oak, Beech, Alder, Birch, Willow, &c.—it is customary in floras to deal summarily with such flowers and term them generally *apetalous*, since, when monochlamydeous, it is the calyx which usually occurs.

Good illustrations of more or less difficult cases are the following.

In the common Arum an inflorescence (*Spadix*) of truly achlamydeous flowers is subtended by one large protective bract (*Spathe*).

In the Willows we have an inflorescence (*Catkin*) consisting of numerous bracts, in the axil of each of which is an achlamydeous flower. The whole catkin is distinguished from a flower by the axillary structures—if the bracts were sepals we should not find stamens or ovaries in their axils.

In like manner the axillary position of the achlamydeous or monochlamydeous flowers of the Birch, Alder, Poplar, Beech, Oak, &c., guides us to their true nature; and similarly with the apetalous flowers of Grasses, Sedges, &c.

Another point arises when, as in Lilies, Hyacinths, Daffodils, &c., the sepals and petals are all alike: close examination of a Lily shows that the three sepals are inserted *outside* and alternate with the three petals, but they are all so similar in shape, colour, texture and other

peculiarities, that it becomes necessary to distinguish this type of floral envelopes as a *Perianth*. *Perianth* (or *Perigone*) is used by some writers to denote all the floral envelopes present: in this case the perianth of a Lily is a *homochlamydeous* perianth, as opposed to the *heterochlamydeous* perianth in which calyx and corolla are well differentiated. In the cases mentioned above the perianth is *petaloid*, since the parts resemble petals; but in other cases—e.g. Rushes (*Juncus*), *Luzula*, Nettles, Elms, &c.—the perianth is *sepaloid*, since the parts resemble sepals more than they do petals.

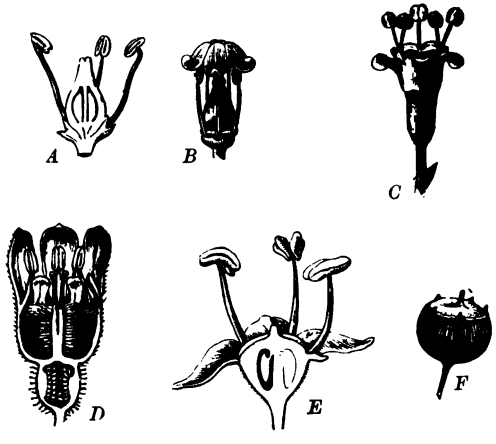


Fig. 22. *A* and *B*, inferior toothed calyx of Vine; *C*, gamosepalous tubular calyx of Guelder Rose; *D*, epigynous calyx-tube, bearing five sepals, of Gooseberry; *E* and *F*, almost obsolete, epigynous calyx of Ivy.

It remains to add that the apetalous condition may be brought about by abortion of the petals, as is well seen in *Clematis* and in some genera of Caryophyllaceæ—e.g. *Cerastium*, where a whole series of forms can be found

with the petals gradually becoming smaller and smaller until none are developed at all—e.g. *C. vulgatum*; or it may be a primitive condition, where petals have never been developed at all, as is probably the case in the Oak, Beech, Hazel, &c. In practice, in the field, these two conditions of affairs cannot be distinguished for systematic purposes, though theoretically they must be sharply distinguished, and are of importance in systematic botany: each case must be judged by comparison with allied forms.

The following afford examples of achlamydeous flowers:—

Willows	Birch	Sweet Gale
Ash	Poplars	Alder,

though male flowers in the Alder and Birch are monochlamydeous.

In the case of the Gymnospermous flower it is not usual to refer to the presence or absence of the perianth; but if the barren scales at the base of the cone represent an incipient perianth the flowers are monochlamydeous. If not, then they are achlamydeous.

The following afford examples of monochlamydeous flowers:—

Clematis	Oaks	Box
Spurge Laurel	Chestnut	Fig
Elæagnus	Walnut	Alder
Elms	Mistletoe	Hornbeam
Mulberry	Mezereon	Beech
Birches	Sea Buckthorn	Hazel.

In most of these cases, therefore, we speak of a *perianth* or *perigone* rather than of calyx or corolla: strictly speaking, the envelope is a perianth if enclosing

stamens only, but a perigone if investing an ovary only, though the distinction is not always maintained by botanists.

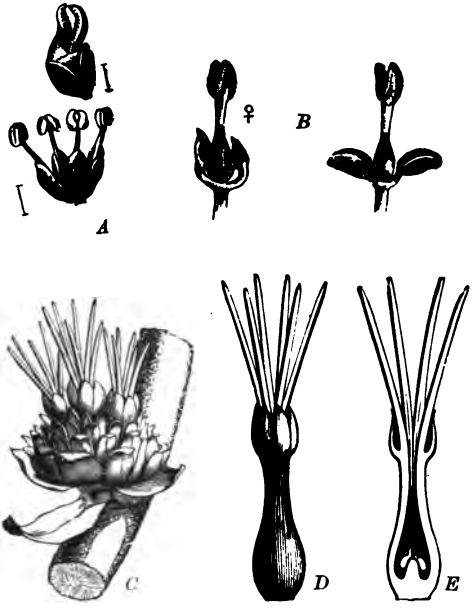


Fig. 23. *A*, perianth of ♂ flower and perigone of ♀ flower of Mulberry; *B*, achlamydeous flowers of Ash; *C*, a group of ♀ flowers of Chestnut; *D* and *E*, single flower showing epigynous perigone.

Dichlamydeous flowers are found in

Barberry	Limes	*Arbutus*
Maples	Horse-chestnut	*Loiseleuria*
Tamarisk	Sumach	*Rhododendron*
Ailanthus	*Ampelopsis*	*Andromeda*
Vine	Spindle Tree	Privet
Rhamnus	Whin	Bittersweet
Gorse	Laburnum	Plane

Broom	*Prunus*	*Erica*
Robinia	*Rosa*	*Arctostaphyllos*
Rubus	Almond	*Empetrum*
Pyrus	Cotoneaster	*Azalea*
Hawthorn	Cornel	*Menziesia*
Ivy	*Lonicera*	Lilac
Viburnum	*Vaccinium*	Tea-tree
Mahonia.		

The next point of importance in regard to the floral envelopes concerns the freedom or union of the sepals or petals. In the Buttercups, Wallflower, Chickweed, Geraniums, &c., direct observation shows that each sepal and each petal originates as a free organ, and remains separate throughout its life, and the calyx and corolla are *polysepalous* and *polypetalous* respectively, as we have seen; whereas in the Pinks, Catchfly, Gorse, Whin, Laburnum, Robinia, &c., the calyx is gamosepalous and the corolla polypetalous, because, as the young sepals develope, their basal parts all grow up as a common ring of undifferentiated tissue. In the Heaths, Bittersweet, &c., again the calyx is gamosepalous and the corolla gamopetalous.

The following afford examples of a gamosepalous calyx:—

Ulex	*Genista*	Robinia
Bittersweet	Tea-tree	*Sarothamnus*
Laburnum	Privet	Lilac.

This condition merges into one where the bases of the sepals are merged into a calyx-tube, as in

Rhamnus	*Rubus*	Almond
Cratægus	*Pyrus*	*Elæagnus*
Prunus	*Rosa*	*Ribes*
Cotoneaster	*Daphne.*	

It should also be noted that such a calyx-tube may pass through every stage of investment of the ovary, from slight perigyny to pronounced epigyny.

In view of the common recurrence of certain types, we must pay attention to the terminology in each of these cases. To begin with the Calyx.

Sepals, when free, are usually green and present evident resemblances to leaves in form, insertion, venation, &c., as may be seen by comparing them in Buttercups, Violets, *Hypericum*, and the terms used in describing them are those in use for simple leaves, excepting that the lamina of a sepal is called the *limb*, and the narrow stalk-like portion the *claw*.

In some cases the calyx, so far as any indication of sepals appears, is reduced to a mere rim or a few minute teeth, even microscopic in size, and is said to be *obsolete*; the word being used to denote that we are not here dealing with a truly monochlamydeous flower, with the calyx absolutely wanting, but with one where the free limbs of the sepals are extremely reduced. Examples are supplied by the Ivy, Rubiaceæ, Compositæ, and Valerianaceæ in abundance, all plants with epigynous flowers.

Sepals are commonly green and herbaceous in texture, but they may be woody, as in some Myrtaceæ, or fleshy (*Sedum*), and are often brightly coloured—e.g. *Clematis*, *Clerodendron*, many Ranunculaceæ and Liliaceæ—and are then termed petaloid.

The gamosepalous calyx usually presents distinctions between the *tube*, corresponding to the coherent claws, and the *limb*, the free portion which corresponds to the limbs of the sepals; and it usually indicates by its teeth, lobes, or other divisions how many sepals have grown up together to form the structure. The aperture at

the junction of limb and tube is known as the *throat* of the calyx.

Such calices are Cup-shaped, Campanulate (Bell-shaped), Tubular, Funnel-shaped, Flask-shaped, &c., terms which practically explain themselves.

In the above examples the calyx is *regular* or *actinomorphic*: that is to say, all the parts—teeth, lobes, veins, &c.—are radiately grouped round an imaginary central axis, so that at least two vertical sections could be cut through the middle and the halves afford similar reflections one of the other, if held up to a mirror. If with these we contrast the calyx of a Pea, Sage, or *Tropæolum*, it will be found that only one vertical section could be cut so that the two halves are symmetrically similar; and in these cases the calyx is said to be *irregular* or *zygomorphic*. A zygomorphic calyx may be *two-lipped*, as in the Gorse; *spurred*, as in *Tropæolum* and Larkspur; or *gibbous*, when the base is somewhat inflated behind as in *Teucrium*.

The calyx of the Potentillas, Strawberry, &c., has coherent stipules forming an *epicalyx*, and although these cases must be distinguished morphologically from the *calyculus* of imbricate bracts, close beneath the calyx of the Pink, Mallow, &c., they are commonly regarded in floras as if the origin was the same in both.

The calyx in many flowers is *persistent*, that is to say the sepals persist after all the other parts of the flower have fallen or altered; but it is *deciduous* when, as in the Wallflower, Cabbage, &c., it falls with the petals. In the *Poppy* the sepals are cast off so early, before the flower expands, that the calyx is termed *caducous*, a state of affairs which may betray the beginner into supposing an expanded poppy flower to be monochlamydeous, until he compares the buds, and observes the scars whence the sepals have fallen.

The *marcescent* calyx of the Mallows, &c., is not merely persistent, but remains as a papery covering to the fruit: in cases where it not only remains, but grows larger as the fruit ripens, the calyx is *accrescent*, e.g. the Winter Cherry (*Physalis*) and many *Dipterocarpaceæ*, *Anacardiaceæ*, &c.

One of the most remarkable types of calyx is the *Pappus* of the Dandelion and many other Compositæ, where the calyx is delayed and obsolete in the flower, but developes a sessile or stalked parachute-like crown of simple or branched hairs as the fruit ripens, and serves as the well-known flying apparatus.

Appendages to the sepals occur in the form of honey-secreting nectaries, and they may assume very peculiar shapes and prominence.

Since these and other peculiarities of the calyx do not apply to the trees and shrubs here concerned, however, I pass on to the consideration of the Corolla.

CHAPTER IX.

THE COROLLA.

Petals—Their texture, insertion, adhesions and cohesions, &c.—Actinomorphy, Zygomorphy—Types of Corolla—Cruciate—Rosaceous — Papilionaceous — Bilabiate — Tubular, Funnel-shaped, Urceolate, Rotate and Bell-shaped Corolla—Ligule and Corona—Hypo-, Peri- and Epigynous Corolla—Petaloid Calyx, Perianth, &c.—Different Corollas on the same Inflorescence.

THE Corolla is the name given to the totality of the petals, and, as we have seen, this is true whether the petals are free and separately inserted, or whether they become united into one whole—a gamopetalous corolla—during their development.

Excepting that petals are very rarely green, and are usually much more delicate than sepals in texture, colouring, and markings of various kinds, what has been said of the calyx applies equally to the corolla and petals as regards insertion, cohesions and adhesions, actinomorphy and zygomorphy, &c.; and the shapes, surface, margin, apex, &c., of petals, like those of sepals, are described in terms of simple leaves, as set forth in Volume II. pp. 22 and 23.

Certain types of corolla are so characteristic, however, and recur so often, that special names are applied to them to save lengthy description. For instance, the *Cruciate* corolla of the Wallflower, where we have four petals all

alike and arranged cross-wise, is typical of nearly the whole of the large Order (Cruciferæ) to which it gives the name, though it is found in other cases also, e.g. *Chelidonium*, Poppy, Spindle Tree, &c. (Fig. 11).

The *Rosaceous* corolla (Fig. 43) of five similar spreading shortly-clawed petals, so arranged that two are entirely outside, two wholly inside, and the other with one margin inside, and one outside in the bud, is again characteristic of many flowers of the Natural Order Rosaceæ besides the Rose, Strawberry, Potentilla, &c.

The *Papilionaceous* corolla (Fig. 44) is zygomorphic, and consists typically of a large *standard* wholly exterior and superior; two lateral *wings* with their upper margins beneath the standard and their lower ones outside the *keel*, a boat-like structure formed of two long petals joined by their lower margins. This form is found in the Bean, Pea, Laburnum, Robinia, Gorse, Whin, Broom, and most other plants of the Natural Order Papilionaceæ.

The *Bilabiate* corolla is gamopetalous and zygomorphic, and consists of a tube, long or short, and a limb divided into two lips, an upper and a lower one, each lip with its own peculiar markings, incisions, and so forth in the different cases. This type again is very characteristic of large groups of plants, though rare in our shrubs and trees; it is well exemplified by the Dead-nettle, Sage, Rosemary, Honeysuckle, &c. (Fig. 142).

Other examples of characteristic gamopetalous corollas are, *tubular* (Tobacco), *funnel-shaped* (Convolvulus), campanulate (Hare-bell), *urceolate* (Heath), where the inflated belly and narrowed aperture suggest an urn; *rotate*, with very short tube and flat, wheel-like, spreading limb, e.g. Pimpernel, Borage, Holly, Elder, Guelder Rose, &c.

It is not uncommon to find a *Ligule* at the angle which the limb makes with the claw, as in the petals of *Lychnis*

Silene, and the perianth segments of *Narcissus*, and, as these are grouped in a circle round the throat of the corolla they are sometimes collectively termed a *Corona*. Similar scale-like appendages are common in many Boraginaceæ, Apocynaceæ, and Gentians, where they often take the form of fringes; as these are not always strictly ligules, the more general term *appendiculate* is frequently applied to the throat in these cases.

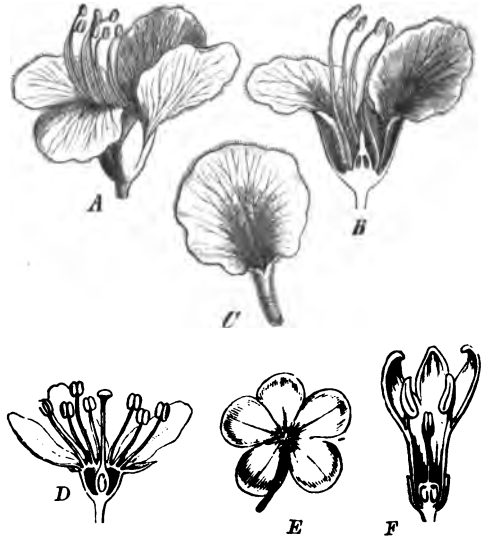


Fig. 24. *A* and *B*, polypetalous hypogynous corolla of Horse-chestnut; *C*, single petal showing claw and limb; *D*, polypetalous perigynous corolla of Blackthorn; *E*, gamopetalous, epigynous rotate corolla of Guelder Rose; *F*, gamopetalous tubular-campanulate, hypogynous corolla of Privet.

Since few of these peculiarities apply to the trees and shrubs to be considered, I pass by further details.

There is one matter concerning the corolla more particularly than the calyx, however, which deserves special consideration.

In the case of hypogynous flowers each petal, or the base of the gamopetalous corolla, springs from the floral axis beneath the carpels or ovary, and whether the stamens are similarly and separately inserted, or whether they are borne on the corolla (*epipetalous*), we must consider the ovary as superior—e.g.

Buttercup	Barberry	Mahonia
Tamarisk	Lime	Maple
Bittersweet	Heath	Ling
Strawberry-tree	Bearberry	Azalea
Rhododendron, &c.		

In perigynous flowers the petals arise from the basal part of the calyx, as in the

Furze	Whin	Laburnum
Robinia	Holly	Blackberry, &c.;

or from the throat of the calyx-tube as in the

Cherry	Plum	Almond
Bird-cherry	Gean	Roses
Red Currants	Black Currants	Gooseberry
Buckthorn, &c.,		

and the ovary is then generally half-inferior.

In epigynous flowers the petals or corolla are inserted on the closed throat of the calyx-tube, or on the top of the inferior ovary, as in

Ivy	Cornel	Honeysuckles
Elder	Snowberry	Wayfaring Tree
Guelder Rose	Whortleberry	Cowberry
Cranberry, &c.		

Another point to be noticed is that not all floral envelopes which have delicate, petal-like segments, or are coloured and corolla-like, are true corollas. For instance, the four white spreading organs of the Clematis look like petals; they are, however, really coloured sepals, the corolla being wanting. Similarly with the purplish-pink, corolla-like perianth of Mezereon; it is really the calyx-tube.

There are other means also by which flowers, morphologically devoid of a corolla proper, nevertheless display coloured organs which at first sight appear to be petals—e.g. the coloured *bracts* of some exotic Cornels, Euphorbias, &c.

Further may be mentioned cases where the corollas of the outer flowers of crowded inflorescences are very different in appearance from those of the inner flowers, e.g. many Compositæ, such as the Daisy and Candytuft, the Guelder Rose, &c. (Fig. 141). In the common Carrot the corolla of the central flower in the umbel is purple-brown, whereas that of all the other flowers is white.

We shall see that the chief functions of the coloured petals is to attract insects; the above facts simply serve to remind us that in Nature the same end is frequently served by various mechanisms or adaptations.

The corolla is gamopetalous in

Elder	Guelder Rose	Honeysuckles
Loiseleuria	*Menziesia*	*Erica*
Azalea	Privet	Bittersweet
Wayfaring Tree	Snowberry	*Vaccinium*
Strawberry-tree	*Arctostaphyllos*	Rhododendron
Ling	Lilac	Tea Tree.

In all these cases, except in the Ericaceæ—e.g. *Vaccinium*, *Erica*, Ling, *Loiseleuria*, Strawberry-tree,

Menziesia, *Arctostaphyllos*, Azalea, and Rhododendron—the stamens are inserted on the corolla (epipetalous).

In all the rest of our trees and shrubs, where the flower has a corolla it is polypetalous—i.e. composed of separately inserted petals.

In the following cases the perianth is gamophyllous, at least at the base and in the staminate flowers:

Daphne	Hippophaë	Fig
Elms	Birch	Beech
Elæagnus	Box	Mulberry
Alder	Oaks	Chestnut.

CHAPTER X.

THE STAMENS.

Andrœcium—The Stamen a foliar organ—Filament, Anther and Pollen—Transitions of leaves to stamens—Metamorphosis of stamens—Insertion, structure, &c., of stamen—Anther-lobes, Connective and Theca—Filament and appendages—Anther and appendages, &c.—Adnate, versatile, basifixed and dorsifixed anthers—Introrse and extrorse anthers—Porous, valvular and sutural dehiscence—Branched stamens—Numbers of stamens—Monadelphous, Diadelphous, &c.—Syngenesious and Gynandrous—Hypogynous, Perigynous and Epigynous stamens—Epipetaly and Antipetaly—Pollen—Structure, shapes and sizes of pollen-grain—Pollinia.

THE technical collective name for the whole of the stamens in a flower is the *Andrœcium*, each stamen being itself a specially modified foliar organ, adapted for the development of pollen. The exceptions to this are rare, but in a few plants with which we are not directly concerned here—e.g. *Naias*, *Callitriche*, and *Casuarina*—the history of their development shows that the staminal organs are part of the axis.

A typical stamen consists of two parts, the *filament*, or stalk, and the *anther*, a two- or four-chambered stouter portion which opens by slits or pores and discharges the usually yellow dust-like *pollen* formed in the cavities. The chambers are called *pollen-sacs*.

The foliar nature of the stamen can be more or less

directly observed in some cases. In the Water Lily, for instance, the outer stamens are ovate or oblong, petal-like organs with a small anther at the tip, and every transition

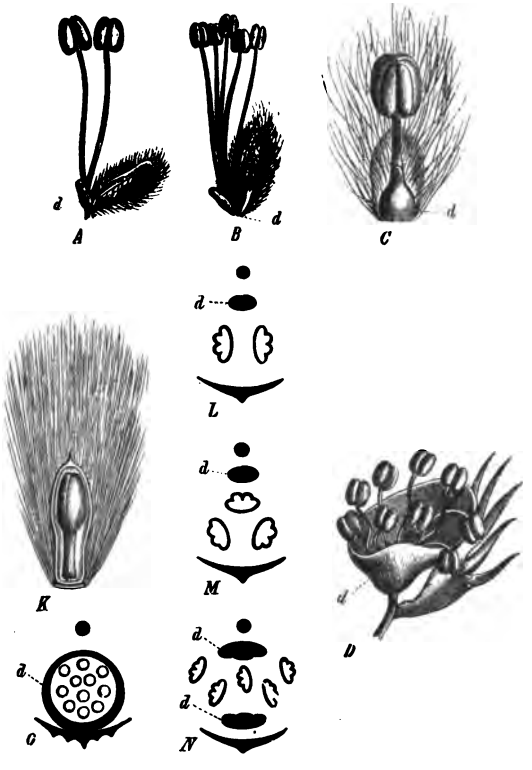


Fig. 25. *A*, *B*, *C*, stamens of Willows; *D*, of Poplar. In each case the stamen is seen to be composed of a slender stalk, the filament, surmounted by the anther. *K*, seed; *L*, *M*, *N*, floral diagrams of ♂ flowers (E and P).

to the normal stamen can be observed as we pass inwards, and in the Pines and Firs the flat, shortly stalked, scale-

like stamens present obvious leaf-like characters, while in the common Indian Shot one flat, petal-like organ alone bears an anther lobe at one of its edges. In another class of cases we find stamens metamorphosed into carpels or petals, or even into green leaves, and this in a few instances is traced to the action of parasitic organisms; while cases are known of buds arising in the axil of the stamen of a flower, though such events are rare and abnormal.

Such more or less exceptional cases of transition and metamorphoses by no means suffice by themselves to prove that a stamen is a leaf; but they suggested the homology to the older naturalists, and when all the facts are taken into account there can be no further doubt on the subject.

Thus, the insertion of the stamens in the less modified types of flower is like that of leaves, and a vascular-bundle passes out from the floral axis up the filament as in the case of a leaf. Again, the anther is covered by an epidermal layer, and in some flowers (e.g. *Lilium*) well-developed stomata are found in this.

It is in the development of the stamen, however, that the clearest evidence of its leaf-nature is obtained, and when this is compared with all we know of the development and structure of leaves elsewhere the homology is unassailable. Since we shall find that pollen-grains are spores, moreover, we have to understand that the stamen is a spore-bearing leaf—i.e. a *Sporophyll*—quite like that of many of the Cryptogams.

In the typical stamen the prolongation of the filament between the anther-lobes is called the *connective*, and the lobes themselves are often termed *thecæ*: each theca may have two pollen-chambers or pollen-sacs or only one, and in the latter case the single chamber usually arises by the fusion of two.

The filament is commonly slender and thread-like, whence its name, e.g. Horse-chestnut, Honeysuckle, but it may be flat and broad (*Erodium*) or dilated (*Ornithogallum*), and many vary considerably in length; when absent, or nearly so (*Cucurbita*, Lilac, Mistletoe), the anther is sessile or subsessile. Various appendages may occur, laterally (*Allium*, *Laurus*), or on the axial face below, e.g. *Cuscuta*, &c.; or, like the hoods of *Asclepias*, outside and above; or spurred as in *Viola* and Ericaceæ.

The anther is commonly oblong and simple, but may be linear, as in Grasses; or convolute, as in *Cucurbita*; horned above or below, as in most Ericaceæ, Melastomaceæ; or tapering to a point, as in *Erica*; or bearded with hairs, as in Hazel and Hornbeam.

The connective is usually narrow, and stops somewhere between the anther-lobes, but it is sometimes broad and may be prolonged to a point or plume. In some Labiatæ it separates the two anther-lobes each at the end of a long, nearly horizontal arm.

The relations of position between anther and filament are of importance in descriptions. In one extreme case the whole length of the anther-lobes remains in contact with the filament and connective, so that they are *adnate*, or as if fixed laterally and by the whole length to the stiff filament; in the other extreme case the filament is attached by so slender a point into the back or base of the connective that the anther as a whole turns on this as on a pivot, and dangles freely in the wind—it is *versatile*. Where the stiff filament tapers into the slender connective, and so appears simply continued into the base of the anther, the latter is *innate* or *basifixed*. In cases where the filament appears fixed stiffly into the middle of the back of the anther, the latter is *dorsifixed*.

Associated with this is the direction of the anther-

lobes with regard to the centre of the flower, for the dehiscing faces may be turned inwards (*introrse*) or outwards (*extrorse*), and various combinations of these characters of attachment to the filament and aspect of anther-lobes occur.

As to the mode of dehiscence of the anther, while it is most frequently effected by means of slits (*sutural*), it occurs in some cases by means of incomplete slits or pores (*porous*) at the base or apex of the anther—e.g. *Solanum*, Ericaceæ, *Polygala*, &c.; or the dehiscence may take place by means of opercular openings (*valvular*) in the sides of the thecæ, the lid of which is an excised piece of anther-wall, e.g. Sassafras, Barberry, and other Berberideæ and Lauraceæ.

Hitherto I have had regard to the simple typical stamen only, as commonly met with, but in many flowers —e.g. Mallows, some Myrtaceæ, and *Ricinus*—the stamens are branched, and in others they are confluent in various degrees, so that we have bundles or groups of stamens, as in Papilionaceæ, *Polygala*, &c., and these groupings are distinguished in descriptive botany.

Monandrous or one-stamened flowers are not common, but they occur in *Euphorbia*, *Zostera*, and a few other plants. In the commoner cases the number of stamens has some relation to that of the other parts of the flower, and the corresponding Greek numerals are prefixed for technical terms—e.g. *pentandrous*, *decandrous*, &c.—and if more than twenty, *polyandrous* or *indefinite*. But these numerical terms apply to the individual free stamens. Where the stamens are equal in number to the sepals and petals the flower is said to be *isostemonous*; where the number of stamens is double that of the petals, the flower is *diplostemonous*. It commonly occurs, however, that diplostemonous stamens do not regularly alternate with the

other parts of the flower: in this case they are said to be *ob-diplostemonous.*

Stamens grouped in bundles, whether by branching or by coalescence of the filaments, are *monadelphous, diadelphous,* to *polyadelphous,* according to the number of bundles.

In cases where the *anthers* are coalescent they are termed *syngenesious,* e.g. Compositæ, Cucurbitaceæ, *Lobelia.*

In some cases the fusion is still more complete, comprising not only cohesion of stamen and stamen, but also adhesion with the gynœcium. The andrœcium is then termed gynandrous; e.g. Orchids, Asclepiads, Aristolochiaceæ, &c.

Where the fusion occurs with the calyx-tube, the stamens are, as we have seen, *perigynous* or *epigynous*; and where with the petals or corolla, *epipetalous.* The stamen opposite a petal, but not necessarily joined to it, is often termed *antipetalous,* and so on.

Pollen is not always, as the name would imply if we observed its etymology, a powdery dust, though it is so in the majority of cases, and each species of pollen-grain has its definite size, shape, colour, and ornamentation, the diameter varying from about 25 μ to 250 μ, and being more or less spheroidal or ellipsoidal, yellow, and covered with spicate or knob-like or other projections, to facilitate the attachment of the grain to insects, the stigma, &c. There is often no relation discoverable between the external peculiarities of the pollen-grain and the systematic position of the plant; but there is between the mode of pollination and these peculiarities, and it is only when all or most of the members of a group are pollinated in the same way that the former relationship exists.

As examples of pollen-grains the student may compare and contrast the following. The large spherical grains of

Cucurbita, with spicate outgrowths and special apertures, covered with lids, for the emergence of the pollen-tubes; the angular pollen-grains of *Tropæolum*, Dandelion, &c.; the filamentous grains of *Zostera*; the winged ones of *Pinus*, *Abies*, and other Conifers, where the outer coat is inflated on each side like a balloon, thus offering a large surface to the wind.

In some cases, e.g. Onagraceæ, the individual pollen-grains do not separate completely into dry powder, but remain loosely attached as if by thin filaments of cobweb; these filaments are drawn-out threads of a viscid substance adhering to the grains.

In other cases the pollen-grains never become isolated at all, but occur in tetrads (e.g. Azaleas, Rhododendrons and other Ericaceæ, some Orchids, species of *Juncus* and *Luzula*, *Anona*, *Drimys*, *Jussieua*, *Apocynaceæ*, *Agave*, *Typha*, &c.), or in packets of 8, 16, or 32 grains closely agglutinated, e.g. many Mimoseæ; while in Orchids and Asclepiads the whole mass of pollen-grains of each anther-lobe remains thus unseparated. Such masses, which may include hundreds of grains, are termed *pollinia*, and each pollinium is removed by an insect owing to certain mechanical adaptations for the purpose.

CHAPTER XI.

THE ANTHER AND POLLEN.

Development of Pollen—Sporogenous tissue—Pollen mother-cells—Pollen-sac — Pollen-grain — Pollinia — Sculpturing of walls—Changes in contents—Pollen of Gymnosperms—Shapes and sizes of pollen-grains—Distribution of pollen by wind, insects, water, &c.—Germination of pollen-grain—Pollen-tube—Vegetative and Generative Nuclei — Homologies — Spermatozoids — Exine and Intine—Markings on the walls—Comparison of pollen-grain to a spore—Germination—Comparison with the spores of Cryptogams.

A TRANSVERSE section of the very young stage of a stamen, which frequently grows far more rapidly than the petals, shows it to be composed entirely of embryonic tissue, but soon after the distinction between anther and filament is established a transverse section of the former shows that several tracts of cells can be made out. An outer layer of cells is already marked out as the epidermis, and in the central part of the connective may be seen a strand of cells remarkable as dividing oftener in the vertical direction than across it, thus forming a strand of tissue which will constitute the slender vascular-bundle continuous from the floral axis through the filament.

The rest of the anther usually shows a more or less four-lobed outline, in each lobe of which one to three or more cells are remarkable for their bright contents and

larger size. These cells, the transverse sections of a corresponding vertical column in each case, are seen to arise by the tangential division of the layer next to the epidermis, and thus lie separated from the epidermis by one cell. They form a mass of spore-producing tissue, and give rise by further division to the *pollen mother-cells.*

The cells separating this mass of spore-producing tissue from the epidermis undergo one or two further tangential divisions, until about three rows of cells separate the sporogenous tissue from the epidermis. The inner of these layers is called the *tapetum.*

Meanwhile the cells between the sporogenous mass and the centre of the anther have been growing and dividing, and one layer of cells next the sporogenous mass completes the *tapetal* layer all round the sporogenous cells.

The number of spore-forming cells, and of divisions preceding their completion, differ slightly in different plants, in relation with differences in the size and shape of the anther and pollen-sacs, but the principle is the same throughout.

When the sporogenous mass has divided by walls in all directions, the resulting pollen mother-cells form a tissue with very thin walls, full of highly refringent protoplasm with large nuclei; these stain well, and yield some of the best examples of nuclear divisions that can be obtained.

Very soon the pollen mother-cells are found to have thick, swollen and lamellated walls and to be separating, and the surrounding cells also break down to a disorganised glairy mass; and we now have the isolated pollen mother-cells floating free in a granular fluid in the four cavities thus scooped out, as it were, in the tissues of the anther-lobes. These cavities are the *pollen-sacs.*

The mother-cells, feeding on the nutritious liquid

in the sac, now enter into division, and each forms four pollen-grains, either by division into two complete cells, each of which then divides again (as occurs in most Monocotyledons), or by the division of the nucleus into two, followed by a repetition of the division before any cell-walls are formed, as occurs in Dicotyledons generally.

In either case the result is the same. Four *pollen-grains*, each a complete cell with a thin cell-wall, protoplasm, and a large nucleus, lie in the swollen and rapidly disorganising shell which is all that remains of the pollen mother-cell.

Just as differences occur in the number of pollen mother-cells developed, so in that of the pollen-grains; but it is also true that whereas in most plants all the pollen-grains soon separate and lie embedded in the fluid formed by the disorganised surrounding cells and remains of the mother-cells, there are a few cases where the pollen-grains do not become free, but remain joined in a tissue in each pollen-sac (most Orchids and Asclepiads), or only partially separate (many Mimosas and Acacias, some Orchids, *Fourcroya*, *Typha*, *Anona*, Rhododendron). Such groups of non-separated pollen-grains are termed *pollinia*.

The freed pollen-grains, living at the expense of the fluid in the pollen-sac, now undergo two sets of changes as they ripen. These concern first the cell-walls, which thicken and become lamellated into an outer protective, cuticularised wall (*exine*), and an inner thin cellulose membrane (*intine*); become studded with the various projections—spikes, warts, comb-like ridges, networks and other sculpturing—which subserve distribution and adhesion to insects and stigmas; and provided with the thin places which facilitate the exit of the pollen-tubes.

These changes concern, secondly, the contents. The

ripe pollen-grain contains not only starch and oil in its rich protoplasm, but its nucleus has undergone complete division into two, usually of different shapes, and each of which has very different functions: occasionally a delicate cell-wall is formed between the nuclei.

Apart from certain differences in shapes and sizes, which however are not greater than occur in the Angiosperms, the stamens of Gymnosperms show essentially the same development as that above described. In each pollen-sac, the number of which differs in the different groups, a spore-producing mass arises as before from the division of cells below the epidermis, and a layer of cells, which eventually become absorbed, is formed around it. The pollen mother-cells formed by division of the archesporium divide each into four pollen-grains, and these float in the fluid of the sac as before.

At the stage where the pollen-grains approach maturity, and are ready to escape by the splitting of the anthers, the essential differences begin to be apparent; for in the Gymnosperm pollen-grain the nucleus not only divides, but its divisions are followed by complete, though delicate, cell-walls formed across the hitherto single cell.

The cases vary in detail, but the following example is typical. The nucleus of the young pollen-grain divides, and a curved cell-wall cuts out a small nucleated cell from the larger one, and this small cell undergoes one or two further divisions.

The ripe pollen-grain thus constitutes a cell-complex. The large cell is in all these cases known as the vegetative cell, and it is this which gives rise to the pollen-tube, and of the other cells the one next to and in contact with the vegetative cell is known as the generative cell.

As regards shape, pollen-grains differ greatly in

different plants. They are spherical or spheroidal in the

Juniper	Hazel	Hornbeam
Elms	Honeysuckle	Spindle Tree, &c.

Much more commonly they are more or less ellipsoid, or oblong to fusiform, as in

Oak	Beech	Willow
Plane	Bittersweet	Ash
Elder	Aucuba	Pear
Gorse	Sycamore	Maple
Holly	Tamarisk	Clematis
Lime	Horse-chestnut	Vine
Virginian Creeper	Laburnum	Rosaceæ, &c.

More curious shapes occur in some plants, however, such as the rounded-ellipsoid grains each with two flanking air-vesicles, or balloons, found in Pines, Larch, &c.; the polyhedric grains of the Alder, the quadrangular pyramids or prisms, or truncated cones of *Ribes*; and even more extraordinary shapes can be found.

Another curious fact is the coexistence of more than one shape in the same flower. This is well seen in the Black Currant, where the grains may be shaped like a tetragonal pyramid, or cone, truncate or not; or a four-angled prism, with the faces plane or curved; or even a globoid or deformed and creased body. No doubt some of such polymorphic grains are imperfect, and the shape varies (as does that of all pollen-grains) according as they are viewed in water, or dry, or in some water-extracting medium such as alcohol or glycerine; but polymorphic pollen-grains are known for many other plants, of which I may mention the Rowan, and are very commonly found of two sizes in different or in the same flowers, e.g. in the Tamarisk.

In Rhododendron, *Arbutus*, and other Ericaceæ they are united in tetrads of four grains each.

As regards size, while the pollen-grains of *Clematis*, *Rhamnus Frangula*, *Ribes nigrum*, &c., average about 20 μ in diameter, they reach an average of 50—55 μ in *Acer*, *Ampelopsis*, *Cratægus*, *Prunus Avium*, &c.; but much smaller and larger grains occur, e.g. those of some species of *Cucurbita*, *Mirabilis*, *Malva*, &c., are particularly large, up to as much as 250 μ in diameter.

When the pollen-grain has been carried by wind, water, insects or other agency to the viscid surface of the stigma, in the case of Angiosperms, or to the micropyle, in the case of Gymnosperms, the protoplasmic contents of the vegetative cell absorb fluid and feed on the sugary solution there exuded.

That this is so can be proved by sowing the pollen-grain in a drop of sugar solution under the microscope and observing directly the changes to be described.

The swollen vegetative cell soon bursts the exine, either by irregularly rupturing it or by boring through one of the specially thin places, and is protruded as a thin tube—the pollen-tube—the extremely delicate cell-wall of which is an extension of the intine. Into the oily, well-nourished protoplasm of this pollen-tube we now see the vegetative nucleus wander, and pass towards the free-growing end; and soon afterwards the generative cell is found to have its wall disorganised and its nucleus following the vegetative nucleus into the pollen-tube. When, as in Gymnosperms, there are other cells in the pollen-grain, they usually remain behind and soon suffer dissolution.

The functions and fate of the vegetative and generative cells are entirely different. The vegetative nucleus sooner or later undergoes disorganisation and disappears in the

protoplasm of the growing pollen-tube; the generative nucleus is either passed on to the end of the tube and handed over to the oosphere direct, or it first undergoes division into two, and *one* of these two is thus handed on, the other becoming disorganised. Or, in some cases, both are handed over to the embryo-sac.

It is clear from the foregoing that the pollen-grain is not a mere cell which elongates into a tube, but that it germinates and forms in its interior a delicate cell-tissue, consisting of two to five nucleated cells, in some cases (e.g. most Angiosperms) not even completely separated off by a cell-wall, but in others (e.g. especially Cycadeæ) very distinctly clothed with cellulose coats.

The fact that the generative nucleus with its surrounding protoplasm—i.e. the nucleated generative cell—always occurs, and is passed into the pollen-tube to be handed over to the oosphere, shows that it is the one cell of this tissue which is of prime importance; while the fact that the other cells vary in number and completeness, and soon undergo disorganisation, or are even not formed at all, indicates that they are of less importance.

All the evidence, therefore, goes to show that we have in these rudimentary tissue formations remnants of some processes which in the ancestors of the pollen-grain had more significance than they have at present, and that the reason they are formed at all as transient and incomplete structures, is due to that conservative principle of heredity which alone explains why rudimentary and now useless structures are developed at all. It is evident that our only hope of explaining what these rudimentary structures represented in the ancestors, is to piece together all the stages of evolution shown by the pollen-grain in its origin in the anther, and we find that the formation of the sporogenous mass and its surrounding degenerated layers

of cells, the development of the pollen mother-cells and their division into fours, and the nutrition of the young pollen-grains, their structure and germination, give us a number of fixed points for comparison which enable us to explain in detail the meaning of all the transient rudimentary structures referred to.

The formation of the pollen-forming mass and its investing cells is in reality a process of development of a sporogenous tissue—i.e. a tissue which gives origin to spore mother-cells and their progeny the spores, and the student can experience little difficulty in seeing that the so-called pollen-grains *are* really spores, as shown by their sizes, shapes, markings, colours, but especially by their becoming free and germinating. Indeed they can be made to germinate and develope in artificial nutritive solutions containing sugar as readily as can the spores of many Cryptogams. It is true we are accustomed to call the outgrowth which the germinating pollen-grain emits the pollen-tube, but this in no way vitiates the comparison, any more than in other cases where terms, invented before the resemblances and differences were understood, vitiate homologies elsewhere. The pollen-grain being a spore, then, the rudimentary tissues which it forms on germination are to be explained as some structures developed by a germinating spore, and must be compared accordingly.

In the same way, having recognised the pollen-grain to be a spore, we shall be prepared to see in the anther a spore-case—a sporangium—and if we find that in other instances the development of spores in a sporangium is preceded by the formation of a sporogenous tissue, tapetum, and so forth, our confidence in the accuracy of the homology is strengthened. And this we find to be the case.

The completion of the proof of homology is seen in the fact that some Gymnosperms have motile ciliated *spermatozoids* in their pollen-tubes, just like those which occur in the antheridia of Cryptogams; and even in higher flowering plants—e.g. Lilies—curved, writhing bodies of this kind occur.

Returning to the pollen-grain itself, then, we have seen that, microscopically examined, a typical pollen-grain, fully mature, is found to consist of protoplasm invested by a cell-wall; it is practically an isolated cell, though in most cases both the investing wall and the protoplasmic contents exhibit complexities which show that we are here dealing with what is more than a simple single cell.

In the first place, the investment consists in the majority of cases of at least two membranes or layers; an outer, firmer, and especially protective layer—the *exine*—diversified by the most varied sculpturing, such as papillæ, spines, warts, ridges, honeycombing, and all manner of combinations of these and other markings; and an inner, thinner, and more yielding layer—the *intine*—devoid of irregularities. In many cases, again, the exine has oily substances smeared on it, and in some grains there are definitely placed, circumscribed, thin areas, looking as if a minute pair of compasses had been used to incise a circle nearly through the *exine*, at which the *intine* can easily be pressed through by the swelling of the contents. In the latter case the excised circles act like lids, and are pushed off as such (e.g. Passion-flower, Gourd, *Morina*, &c.) in the process of germination. These thin areas, or windows, are places for emergence of the pollen-tubes, and remind one forthwith of the very similar thin areas which facilitate the emergence of the germinal hyphæ in many fungus-spores

where the outer wall is thick and strong. In both cases the similarity is heightened by the outer walls being cuticularised, whence there would be difficulty in the absorption of water by the protoplasmic contents but for these permeable spots. Not all pollen-grains have so highly differentiated an outer coat, however, e.g. *Zostera* and other Naiadaceæ as well as some other aquatic plants, and the grains of *Orchid pollinia*, &c., are devoid of a definite exine, and in some cases the differentiation into two coats is either very slight (e.g. *Senecio*) or confined to special areas (*Onagraceæ*, *Cobœa*, &c.).

When the pollen-grain is placed in a drop of dilute sugar solution, such as is found naturally on the stigmatic surface of an ovary, or may be prepared artificially, and the following processes traced step by step with the microscope, a series of changes occur which justify still more our comparison of the grain to a spore; for the pollen-grain *is* a spore, and shows its nature now by acting as such.

The protoplasm in the interior of the ripe grain when first sown is, as we have seen, a granular mass of cytoplasm with a well-developed nucleus in it, as well as variable quantities of oily or carbohydrate food-materials. This now absorbs water and swells, and its nucleus divides, and a delicate cell-wall may or may not be developed between the two nucleated masses of protoplasm which result from the division. This wall is so arranged that it cuts the pollen-grain into two unequal cells. The larger of the two is the vegetative cell, and the smaller the generative cell of the pollen-grain. Meanwhile, the pressure of the swelling protoplasm is stretching the exine more and more, and the vegetative cell, feeding on the sugar, oil, and other food-materials as it does so, grows out as a tubular prolongation

through one of the thin areas of the exine, its nucleus passing into the tube (pollen-tube). The nucleus and protoplasm of the generative cell follow suit, the cell-wall between generative and vegetative cells disappearing, and the former divides into two generative nuclei as it enters the tube.

The germinated pollen-grain now consists of the nearly exhausted grain behind, and the delicate pollen-tube with the protoplasm in it, carrying at its anterior end the vegetative nucleus, followed by two generative nuclei.

It is one of these generative nuclei which is eventually handed over to the egg-cell (oosphere) of the ovule to fertilise it.

These are the essentials of the process of germination of the pollen-grain, and they show that it is a spore, and a spore, moreover, in which there are structures and phenomena which must arouse our curiosity as to their explanation. We find that they represent structures and phenomena, here reduced and condensed, which recapitulate events in the germination of spores in the Cryptogams.

In preparation for the comprehension of these, however, the student must observe that not all pollen-grains behave exactly as above in detail, though they do so in principle.

In some, for instance, the vegetative and generative cells, though their nuclei are divided off from one another, have no recognisable cell-wall developed between—this is the common rule in the higher flowering plants. In others the first division of the nucleus and cytoplasm of the grain results in the formation of a large vegetative cell, as before, separated by a wall from a smaller cell; then succeeds division of the smaller of the cells, and it is one of these last formed which becomes the cell

whose nucleus passes into the tube, and there divides into two generative nuclei.

In these cases, which are especially characteristic of Gymnosperms, we get important clues to the meaning of the processes, for the two- or three-celled rudimentary tissue is shown to be a reduced prothallus, one cell of which represents an extremely reduced antheridium, the divided nuclei of which can only represent the antherozoids. In the higher flowering plants we cannot trace these homologies in detail; the reduction has gone so far that only one cell—the smaller—represents the reduced antheridium, and its two generative nuclei the antherozoids, the vegetative cell being all that there is to represent the prothallus.

CHAPTER XII.

THE PISTIL.

Gynœcium—Carpels of Conifers and of higher flowering plants—Monocarpellary ovary of Leguminosæ, &c.—Sutures and Placentæ—Style and Stigma—Sessile stigma—Polycarpellary pistil of Buttercup, Clematis, &c.—Placentation—Open and closed carpels—Naked and boxed-in Ovules—Gymnosperms and Angiosperms—Apocarpous and Syncarpous pistil—Bicarpellary ovary of Willows, Poplars, &c.—Parietal and axile placenta—Hypogynous, Perigynous and Epigynous flowers—Superior and inferior ovary—Number of carpels—Abortion of stigmas, &c.—Entomophilous and Anemophilous flowers—Examples of Hypogyny, &c.—Of Apocarpy, &c.

THE pistil, the terminal or central part of the flower, is composed of one or more carpels, and is sometimes termed the *Gynœcium*. We shall see that in the Conifers the carpellary-scales, bearing the ovules—the young and as yet imperfect seeds—on their face, are of the nature of leaves, and like ordinary leaves are flat, open structures. In the higher flowering plants, however, each carpellary leaf-incept, as it developes, becomes so folded that it either grows together at its edges, or joins by each edge to the edge of another carpellary leaf, so that some sort of hollow box is formed, to the sides or base of which the ovules are attached.

This is well illustrated by any Leguminous plant such as the Gorse, Whin, Broom, Laburnum, Robinia, &c., or

by a common Pea, the fruit of which is the well-known pod (*Legume*) so characteristic of all these plants. Here the centre of the flower produces one terminal carpel, the leaf-like texture, venation, colour and even shape of which indicate its nature: it corresponds to a more or less oblong leaf, folded on the midrib and the margins brought together in front, so that the minute young ovules—the future seeds—are boxed in.

Exactly the same state of affairs can be traced in the flower of a Plum, Cherry, Almond, or other member of the genus *Prunus*, only here the carpel is apt to be smaller and it only contains one ovule. In the flowering White Cherry of the gardens, indeed, the leaf-nature of the carpel is so dominant, that it usually unfolds more or less as an ordinary green foliage-leaf and bears no ovules —i.e. it becomes barren.

If, now, we carefully examine the young pod—the folded single carpel—of a Pea, &c., we find, first, that its midrib is turned outwards, or away from the axis, and is termed the *dorsal suture*: while its inner conjoined edges are turned towards the central axis and form what is termed the *ventral suture*. The word suture, or seam, was suggested to the older botanists because they were taken with the notion of these edges being brought together and fastened, so to speak, as if sewn up: a very superficial way of looking at the matter.

It will be found further that the ovules are attached to the ventral suture, a fact anyone can verify by splitting open a green pea-pod.

At the apex of this closed box, or young pod, the tip of the carpel is drawn out, as it were, to a short stalk-like process termed the *style*, and on the end of this style is a small surface which receives the pollen from the stamens, and is called the *stigma*.

Here, then, we find that the pistil of our Pea, Laburnum, Plum, &c., consists of a box-like structure composed of one carpel (*monocarpellary*) which completely encloses in its cavity one to several ovules, and which terminates in a style ending in a stigma. Such a box is called an *Ovary*, because it contains the ovule or ovules: and an ovary always has a stigma but not always a style, the stigma being *sessile* on the ovary if the style is absent.

If we now look at the pistil of the Buttercup—that of a Clematis, or a Strawberry, Blackberry, Raspberry, &c., would show the same—we find on the raised central termination of the floral axis not one, but many carpels, each essentially like that of the Pea, Plum, Cherry, &c., just examined. (See Fig. 14.) It is true that they are very small, and each contains but one ovule: nevertheless each is a box-like ovary with a minute hook-like termination ending in a stigmatic surface, and the only essential difference is that in this case the style is so short that the stigma is sub-sessile, and that there are numerous separate carpels (*polycarpellary*), each forming one closed ovary containing an ovule.

That portion of the inside of the ovary to which the ovules are attached is termed the *placenta*; so that in the Pea, Laburnum, &c., the placenta is on the ventral suture, and the *placentation*—i.e. the mode of arrangement of the placentæ—is *sutural*. In other cases it is *basal*, and there are yet other forms met with.

We see then that an essential and fundamental difference between the carpel and ovules of a Conifer and of a higher flowering plant is, that, whereas in the former the carpel is *open* and has the ovules exposed, *naked*, on its surface, in the latter the carpels are *closed* and cover up the ovules as in a box. Hence the Conifers are termed

naked-seeded—*Gymnosperms*—while the higher flowering plants are termed covered-seeded—*Angiosperms*. Since the Gymnosperm has no closed ovary, it is also devoid of style or stigma, and the pollen falls direct on to the exposed ovules: in the Angiosperm, on the contrary, there is always a stigma, and generally a style, and the pollen cannot reach the ovule direct, but must fall on the intermediate stigma.

In the cases we have so far examined the closed carpels are inserted singly and separately on the floral axis and each forms a box-like ovary by itself.

In all cases where the carpels are thus separate the pistil of isolated carpels is termed *apocarpous*.

Now let us examine a pistil which consists of two carpels, placed face to face, and which, as development proceeds, grow together at their contiguous margins, so that the right-hand margin of the one fuses with the left-hand margin of the other in each case: such a bicarpellary ovary is well exemplified by almost any Willow or Poplar (Fig. 22), and as the illustration shows we have again a box-like (here flask-shaped) ovary, but composed of two *united* carpels, and termed *syncarpous*. The ovules are as before inserted on placentæ belonging to the conjoined margins, but since these margins belong to two different carpels in each case, and there are two placental series on the inner walls of the box, we distinguish them as *parietal* placentæ (Fig. 22, *P*—*R*). The Willow ovary also has a style and stigma, but the latter is double, indicating one for each carpel (Fig. 22, *E*—*H*).

Had we chosen the pistil of a Maple we should find two carpels as before, but the conjoined margins so inturned as to meet in the axis of the ovary, bringing the ovules to the centre and dividing the ovary into two chambers (Fig. 42). This kind of placentation is termed *axile*.

If *Euonymus*, the Spindle Tree, had been selected, the results would be the same, but *four* carpels are concerned (Fig. 124); and the same in the Holly (Fig. 109). In the Lilies, Hyacinth, *Ruscus*, &c., there are three

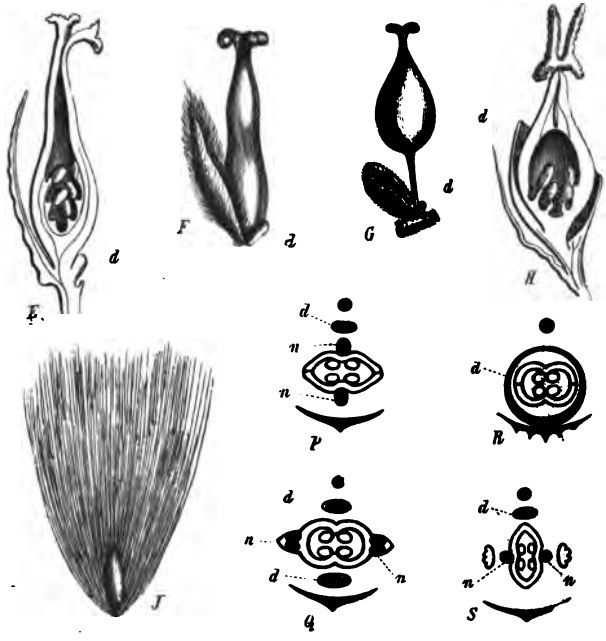


Fig. 26. *E*, *F*, and *G*, ovaries of Willows, *E*, in vertical section, showing the ovules; *H*, similar section of ovary of Poplar. *J*, seed. *P*—*S*, floral diagrams of pistillate flowers, in each case the ovary is seen composed of two carpels with parietal placentation (E and P).

carpels thus joined into a three-celled (*tricarpellary*) ovary with axile placentation; and in the Heaths, Strawberry-tree, and others, we have similarly syncarpous ovaries of five carpels.

Hitherto the syncarpous ovaries selected have been

superior and the other parts of the flower hypogynous; but exactly the same series of events may occur with perigynous and epigynous flowers in which the ovary is inferior. Thus, in the Rose the apocarpous pistil is

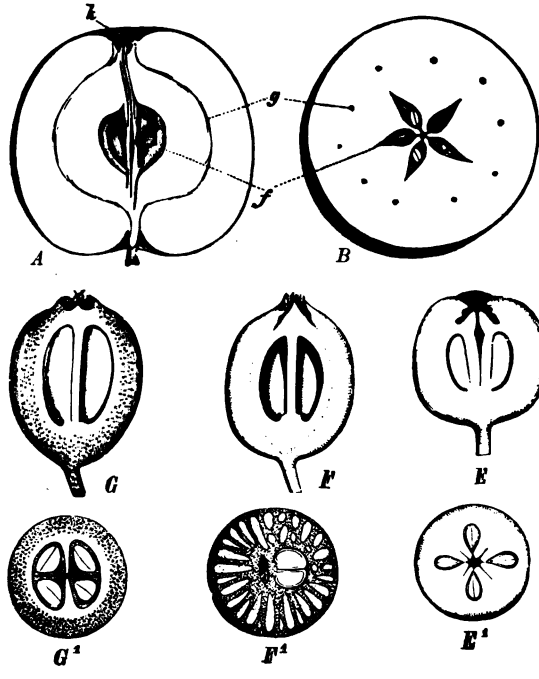


Fig. 27. *A*, *B*, Apple, showing five carpels, *f*, embedded in fleshy calyx-tube; *E*, *E*¹, Rowan, showing four carpels; *F*, *F*¹, White Beam Tree, showing obliteration of all but one of the carpels as the fruit ripens; *G*, *G*¹, Service Tree, showing four carpels (E and P).

immersed in the urn-shaped fleshy calyx-tube (Fig. 129); and in the Apple, Pear, Rowan, Hawthorn, &c., the calyx-tube grows round the more or less syncarpous pistil and renders it completely inferior (Fig. 27).

The Cornel, Elder, Honeysuckles and their allies afford numerous examples of bi- and tri-carpellary inferior ovaries; and in the Bilberry, Cranberry, Cowberry, &c., we have instances of four or five carpels thus fused into an inferior ovary.

It is not always easy to determine the number of carpels in the field; but in the numerous cases where the stigma is lobed the number of its divisions usually indicate the number of carpels, just as do the placentæ and chambers of the ovary: nevertheless there are a few exceptions to the rule, and the question whether a flower is monocarpellary, or bi- or polycarpellary is occasionally difficult to answer forthwith. This difficulty is sometimes due to the abortion of one or more carpels as the flower ages, and this abortion may be confined to styles or stigmas, or to fusions, as is very commonly the case with stigmas on a simple style.

The rule is that the stigma of *entomophilous* flowers —i.e. such as are pollinated by insects—are small and sticky, serving to catch the pollen, which usually has a rough papillose coat in such cases, as the insect rubs it against the viscid surface: in wind-pollinated (*anemophilous*) flowers, on the other hand, the rule is that the stigmas are large or abundantly branched, feathery, &c., and offer a large surface to the pollen-laden wind.

The pistil is apocarpous in

Clematis	Blackberry	Dog Rose
Eglantine	Field Rose	Raspberry
Dewberry	Burnet Rose	Downy Rose
Plane.		

When only one carpel composes the ovary, the pistil is more accurately described as monocarpellary.

The pistil is monocarpellary in

Barberry	Gorse	Broom
Robinia	Plum	Bullace
Bird Cherry	Cherry Laurel	Spurge Laurel
Elæagnus	Mahonia	Whin
Laburnum	Cherry	Gean
Blackthorn	Portugal Laurel	Almond
Mezereon	*Hippophaë.*	

In the rest of the angiospermous trees and shrubs here concerned the ovary is syncarpous. It is composed of two carpels in

Willows	Birch	Hazel
Walnut	Elms	Mulberry
Bittersweet	Privet	Red Currant
Black Currant	Sycamore	Dogwood
Poplars	Alder	Hornbeam
Sweet Gale	Fig	Tea Tree
Lilac	Ash	Gooseberry
Maple	Norway Maple	*Aucuba.*

In all but a few of these the placentation is *axile*: the chief exceptions are the following, in which it is *parietal*:—

Willows	Gooseberry	Black Currant
Poplars	Red Currant.	

The ovary is tricarpellary in the following:—

Butcher's Broom	Horse-chestnut	Wayfaring Tree
Honeysuckles	Tamarisk	Elder
Guelder Rose.		

But it should be noted that the number may vary, by abortion of one or more of the carpels, in all but the first three of the last series. The placentation is usually axile.

Four carpels are the rule in the following :—

Holly	Spindle Tree	Virginian Creeper
Heath	*Vaccinium*	*Rhamnus*
Vine	Ling	*Erica*
Menziesia.		

And in these cases also the placentation is axile.

In the following the ovary is composed of five carpels :—

Lime	Sumach	*Cydonia*
Arbutus	*Andromeda*	Azalea
Ailanthus	*Pyrus*	Ivy
Bearberry	*Loiseleuria*	Rhododendron.

In other cases the numbers vary from two to five. The placentation is as a rule axile.

Examples of flowers with the ovary superior, the rest of the parts being hypogynous, are afforded by

Clematis	Mahonia	Maple
Sycamore	Norway Maple	Vine
Tree of Heaven	*Erica*	*Arbutus*
Azalea	*Andromeda*	*Menziesia*
Ash	Lilac	Birch
Elms	Mulberry	Tea Tree
Barberry	Tamarisk	Lime
Holly	Horse-chestnut	Virginian Creeper
Sumach	Ling	Rhododendron
Bearberry	*Loiseleuria*	*Empetrum*
Privet	Bittersweet	Alder
Fig.		

The male flowers of the Birch, Alder, Oaks, Beech, Chestnut, Hazel, Hornbeam, Walnut, &c., having no ovaries, cannot properly be described as hypogynous, though morphologically they may be so considered (see pp. 232–263).

It should also be noted that in gamopetalous flowers with epipetalous stamens—i.e. where the stamens are inserted on the corolla-tube—the hypogyny is decided by the insertion of the corolla beneath the ovary; e.g. Privet, Lilac, Tea Tree, Bittersweet.

In the Ash, where neither calyx nor corolla exists, it is decided by the insertion of the stamens beneath the ovary.

In the unisexual (*diclinous*) flowers of the Fig, Mulberry, &c., and more especially in the achlamydeous flowers of the Willows, Poplars, and Sweet Gale, where there is no ovary in the staminate flowers and no stamens in the pistillate flowers, we have to assume the hypogyny, or infer it from comparison with other forms.

The ovary is superior, or half inferior, with the other parts more or less perigynous, in the following:—

Buckthorn	Spindle Tree	Whin
Laburnum	*Prunus*	*Rosa*
Daphne	Plane	Alder Buckthorn
Gorse	Broom	Robinia
Rubus	Almond	*Elæagnus.*

In some of these cases the perigyny is very slight, the stamens and petals, or both, being inserted at the base of or on the sides of a very minute calyx, or only just removed away from the axis. This difficult point will arise in Gorse, Whin, Broom, Robinia, Laburnum.

In the Plane the chief difficulty arises from the inconspicuousness of the perianth. In *Daphne* and *Elæagnus* the stamens are inserted on a calyx-tube bearing no petals.

Flowers with an inferior ovary, and the rest of the parts epigynous, are found in the following:—

Pyrus	*Cotoneaster*	Ivy
Aucuba	Elder	*Symphoricarpos*
Vaccinium	Hornbeam	Hazel
Chestnut	Hawthorn	*Cydonia*
Ribes	Dogwood	*Viburnum*
Lonicera	Oaks	Walnut
Beech.		

It should be noted, however, that the epigyny is in some cases only discernible by the position of the minute perianth in the pistillate flowers — e.g. Oaks, Beech, Walnut, Hornbeam, Hazel, Chestnut — the staminate flowers being morphologically hypogynous, though there is no ovary present to which the insertions can be referred.

CHAPTER XIII.

THE OVULE.

Origination from a Placenta on the carpel—Nucellus, Integuments and Micropyle — Chalaza — Embryo-sac — Coats — Sizes and numbers—Erect, Suspended, Horizontal, Pendulous and Ascending ovules—Orthotropous, Campylotropous and Anatropous ovules—Hilum, Chalaza and Raphe—Positions as regards axis—Marginal, Parietal, Superficial, Axile and Free-central Placenta —Development of ovule—Sporogenous cells, &c.—Mother-cell of Embryo-sac—Development of Egg-apparatus—Embryo-sac nucleus — Oosphere—Antipodal cells—Endosperm—Corpusculum of Gymnosperm—Archegonium—Homologies.

THE rounded structures found in the ovary or on the carpels, and which are to become the seeds, are called Ovules, and in most cases they arise from the carpellary leaves, at the margins or other places where they are attached (placenta). Before going into details we will note some characters used in describing the ovule.

In rare cases the ovary contains a single ovule, springing from its base and standing erect. A longitudinal median section through such a typical ovule (e.g. *Buckwheat, Pinellia,* &c.) shows an ovoid or pyriform *nucellus,* invested from below with one or two *integuments,* which nearly close it in above at a point opposite the base of attachment: the aperture left uncovered is the *micropyle,* and is the minute passage into which the pollen-tube penetrates eventually.

At the base of attachment a delicate strand of vascular tissue enters, and through this strand the water and food-substances necessary to feed the ovule pass: in many cases this strand is carried through a distinct stalk (*funicle*), in others the ovule is sessile. The region where the strand merges into the base of the ovule is called the *chalaza*.

In the nucellus there is a cavity called the *embryo-sac*, because the new plantlet (*embryo*) will be formed in it later.

With these fixed points to guide us, we may now examine a few differences observable in ovules.

Many have only one integument as in Compositæ, &c., or even none as in Mistletoe, &c., and the point has its significance in descriptive botany.

In many ovaries the ovules are numerous and small (Orchids), or few and large (Bean), or there is only one (Buttercup).

With respect to the ovary containing it, an ovule may be *erect* when standing up from the base; or *suspended* when hanging from its roof. When the long axis of the ovule is brought at right angles to the vertical it is *horizontal*: it is *pendulous* when obliquely suspended from near the top, and *ascending* when obliquely rising from near the base.

If we agree that a central line drawn from the micropyle to the chalaza through the axis of the ovule is its longitudinal axis—or, shortly, its axis—the following technical peculiarities are to be noted.

The ovule is *orthotropous* when the chalaza is below and the micropyle vertically above it, e.g. *Polygonaceæ*, many *Urticaceæ*, *Aroideæ*, *Cistaceæ*, &c.

If the axis is curved, by one side of the ovule growing faster than the other, so that the micropyle is brought

over to near the basal chalaza, and the axis of the ovule curved like a horse-shoe or crescent, the ovule is *campylotropous*, e.g. Cruciferæ, Capparidaceæ, Resedaceæ, Caryophyllaceæ, Chenopodiaceæ, &c.

When the chalaza is carried forwards so as to invert the ovule by the growth of the funiculus, which is fixed along the side of the ovule, and brings the micropyle down close to the apparent juncture with the stalk, the ovule is *anatropous*. This is by far the commonest form, and the continuation of the vascular strand runs as a cord (*Raphe*) up the side and parallel with the axis of the ovule.

The place where the free part of the funicle—i.e. the stalk—passes into the ovule as a whole, will break across when the seed falls, and the scar which is left is called the *Hilum*. In the *orthotropous* and *campylotropous* ovules hilum and chalaza coincide, but in *anatropous* ovules they do not—the hilum is here separated from the chalaza by the whole length of the ovule proper—i.e. the raphe.

Some ovules are half-anatropous (Primulaceæ, Leguminosæ, &c.), half-campylotropous, &c., but the special terms coined for these cases are superfluous.

Anatropous ovules are so common that differences respecting their orientation in the ovary are useful. If we regard that side along which the raphe runs, it may be turned towards or away from the ventral suture of the carpel, and these characters have been employed in distinguishing several closely allied plants or families—e.g. *Euphorbia* has the raphe ventral and *Buxus* has the raphe dorsal, but in two species of the same genus (e.g. *Euonymus*) we may have pendulous ovules with dorsal raphe and ascending ones with it ventral: the point depends largely on the displacement of the placenta of the carpels, higher or lower as the case may be. Like

all such characters it must be used together with others. Still the character is useful as an indication—e.g. all the Umbelliferæ have pendulous anatropous ovules with a vertical raphe, and the same with the closely allied Araliaceæ and Cornaceæ. In the allied Caprifoliaceæ, however, both dorsal and ventral raphe occur, with similar ovules.

The typical place of origin of the ovule is, as we have seen, the margin of the carpel, and in the vast majority of cases this is where it occurs, the insertion (placentation) as regards the ovary or carpellary leaf differing according as the carpels are free (marginal placentation) or syncarpous (parietal and axile placentation, &c.). In rare cases the ovule terminates the floral axis as in *Taxus*, *Naias*, *Piper*, *Polygonum*, or is produced just beneath the actual apex as in Compositæ, Primulaceæ. In a few rare instances the ovules arise from the surface of the inner walls of the ovary (*Butomus*, *Nymphæa*), and the placentation is *superficial*.

Several cases, formerly doubtful, turn out to obey the general rule that the placentation is originally marginal. In *Mesembryanthemum* the ovules arise in the young ovary on the inner margins of the infolded carpels, but by displacements later they come to appear on the outer walls and as if from the dorsal sutures, and similar cases occur in *Punica* and *Melastomaceæ*.

In the free-central placentas of Caryophyllaceæ and Primulaceæ, again, the ovules do not spring from the axis, but from the basal portions of the carpels. Since these cases do not concern the plants here treated, however, I pass by the details.

When the young carpel has attained the stage of a definite flattened or curved outgrowth of embryonic tissue, either free or joined to neighbouring carpels, one

or more minute humps of embryonic tissue arise either on its surface, usually at or near its margin, or from the axis at its base, and develope into the ovule or ovules.

Taking the commonest case as the type, this embryonic emergence is seen to start by the bulging up of the tissue of the placenta, owing to increased growth and cell-division of a few sub-epidermal cells, and rapidly assumes the form of an egg-shaped protuberance the long axis of which curves over as it rises. This lump is composed entirely of embryonic tissue, but at an early stage two signs of differentiation appear in it: certain external cells in a zone below the dome-shaped apex protrude by more rapid division and raise a rim which proceeds to stand out from the dome, at first like an egg-cup round an egg; while a cell just beneath the epidermis at the apex of the dome becomes remarkable for its size and the brilliancy of its protoplasm and nucleus. This latter is the spore-forming tissue (*archespore*), while the rim of investing cells is the inner *integument* of the ovule; the egg-shaped protuberance which gives rise to both being the *nucellus* of the ovule.

As the nucellus rapidly enlarges, by the growth and division of its cells, a second rim-like investing layer may arise outside the first and proceed to overlap closely the first integument as a second or outer one.

Meanwhile, the spore-forming tissue divides into two cells by a wall at right-angles to its long axis, and the lower of the two cells soon divides again by one or two walls parallel to the first one, and we thus have a row of three or four cells in the dome of the nucellus. Of these cells the upper ones soon degenerate and are absorbed by the lower one, which is the mother-cell of the embryo-sac.

Meanwhile, the curvature of the nucellus continuing, the two integuments close up over the dome and nearly meet there, but leave a narrow passage—the micropyle—between them.

While these processes are approaching completion the embryo-sac mother-cell undergoes a division by a wall across its middle, and each of the two cells thus formed usually divides again by a parallel wall; so that we now find the axial row of cells of the nucellus terminated by four cells, capped above by the degenerating cells referred to above, which are rapidly undergoing disintegration, trapped as they are between these four cells and the epidermis.

Next, the lowermost of the four cells, developed from the embryo-sac mother-cell, begins to enlarge at the expense of the other three, as well as at that of embryonic cells of the nucellus in the immediate neighbourhood, and becomes the embryo-sac.

At this stage, therefore, the typical anatropous ovule shows the following features.

The nucellus, invested by two integuments, between which, at the organic apex, is the micropyle, is turned sharply back on its attachment; a sort of broad stalk, known as the *raphe*, and up which a vascular-bundle runs in connection with the bundles of the carpel, lying closely on it. This bundle ends at the organic base of the nucellus—termed the *chalaza*. Inside the nucellus, towards the micropylar end, is the young embryo-sac filled with a mass of nucleated protoplasm, and pressing, as it enlarges, not only on the cap-cells and tapetum above, but also on the surrounding cells of the nucellus.

The embryo-sac now begins to enlarge considerably, evidently at the expense of the cap-cells and tapetum, as well as at that of the surrounding nucellar tissue, for

we see these cells becoming disorganised and collapsed, and their swollen remnants gradually disappearing.

As this goes on, the single nucleus of the embryo-sac divides, and each daughter-nucleus with its complement of cytoplasm passes to the opposite ends of the sac, a large vacuole appearing between them. At each pole, enlargement and nutrition proceeding, each nucleus divides again, and so produces two nuclei at either end; and there each of the pair undergoes a further division at right-angles to the last, making eight nuclei in all—four at each end.

Then one nucleus from each polar four passes slowly towards the centre of the sac, in the cytoplasm, where they come into contact, and sooner or later fuse more or less completely, and form the *embryo-sac nucleus*. One of the upper three nuclei then rounds off as the *oosphere*, while its two neighbours form a pair termed the *synergidæ*; and the three nuclei at the basal end obtain these cell-walls round their investing protoplasm and form the so-called *antipodal cells*. The synergidæ and oosphere constitute the "*egg-apparatus*" of the embyro-sac, and the ovule is now mature, and its oosphere ready to receive the nucleus and protoplasm brought to it by the pollen-tube—that is to say, it is ready for fertilisation.

The differences met with in various types of Angiosperms from the above description refer to details only, but in the Gymnosperms some of these details are of fundamental importance, and must be carefully noticed.

The origin of the carpel and the hump of embryonic tissue on it, which is to form the nucellus, follows essentially the same course; and the assumption of the anatropous position, uprising of the integument, and formation of the micropyle also present no features remarkably different.

Here also the archespore arises from a sub-epidermal cell, and although it usually becomes sunk deep in the nucellus owing to the growth and repeated bipartition of the cells above it, even this is not unknown in Angiosperms. Moreover the development of the tapetal cells, and that of the superposed cells produced by the repeated division of the archespore, occur here as before, and the embryo-sac is developed from the lower of these cells as described in the previous case.

The really essential points of difference refer to the processes in the maturation of the embryo-sac.

The nucleus of the embryo-sac divides, and each daughter-nucleus repeats the division, and so on, until the enlarging embryo-sac, growing at the expense of surrounding nucellus cells, is filled with a delicate thin-walled tissue of nucleated cells, which has received the name of *endosperm.*

Then, while the endosperm and the embryo-sac are still growing, two or three (or more) of the superficial cells, at the micropylar end of this endosperm, begin to be distinguishable by their larger size and more brilliant protoplasm, and assume an oblong shape.

Following the history of any one of these cells as typical of the rest, it grows much larger than any of the endosperm cells around, its upper end being separated from the nucellus only by its own cell-wall, and sooner or later undergoes a transverse division above, cutting off a small cell which then undergoes division by two walls at right-angles to the transverse wall and to each other. Thus the oval large cell is crowned by four very small ones in a rosette. Next a very small cell is cut off from the large oval cell below this rosette, and grows up like a wedge between the four rosette-cells, driving them apart in the form of a sort of chimney, in the canal of which

the protoplasm forms a plug. The four rosette-cells may undergo a further horizontal division and become eight, and other differences in detail may occur, but the above typical example is not materially affected by these details.

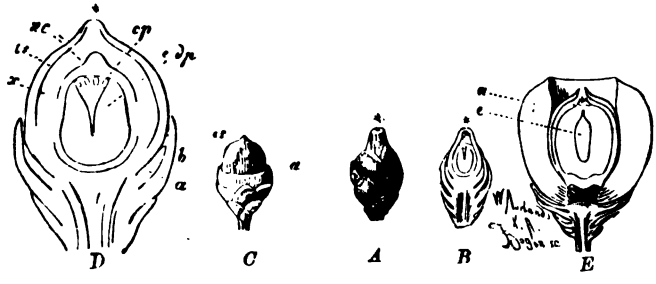


Fig. 28. Simple orthotropous ovule of the Yew. *A*, the mature ovule seen from without; *B*, the same in section; *C*, the same ripened to a seed, all slightly magnified. *D*, the ovule of stage *B* more highly magnified; *a* commencement of arillus; *b* scales of cone; *nc* nucellus; *is* integument; * micropyle; *edp* endosperm filling the embryo-sac; *cp* archegonia. *E*, the seed, at stage *C*, in section and more highly magnified; *a* arillus; *e* embryo in the endosperm filling the embryo-sac.

The large oval cell was long known as the *Corpusculum*—a name given to it by Robert Brown, who discovered it in 1834—but we shall find that this term, now obsolete, does not help us to understand its nature, and the best term to employ for the oval cell, together with its rosette, &c., is *Archegonium*.

This archegonium consists of two parts: the large ovoid *venter*, sunk in the endosperm, and the rosette of *neck-cells*, flush with the boundary between the endosperm and the nucellus. The small plug-like cell which protrudes between the neck-cells is known as the *ventral canal-cell*, and it opens the neck and subsequently affords a passage through it by dissolving. The large nucleated

mass of protoplasm in the venter is the *oosphere*, which after fertilisation becomes the embryo.

If we review the processes above described in the ovules of Angiosperms and Gymnosperms in the light of what is already known, it is evident that the initiation of the sporogenous cells, of which one gives rise to the embryo-sac, is a process of formation of sporogenous tissue, with the accompanying development of investing cells; and the embryo-sac becomes recognisable as a *Spore*. The initial difficulty which the student may experience in clearly grasping this important homology is due partly to the terminology, and partly to the fact that this spore (the embryo-sac) does not become free: if it escaped, as does the pollen-grain, he would have less difficulty in seeing the resemblances. But there are plenty of cases of undoubted spores of Cryptogams which do not escape from their sporangium before they germinate, and since all the processes in the young nucellus which lead to the formation and completion of the embryo-sac—e.g. the development of the archespore and tapetum—are exactly comparable to the establishment of sporogenous tissue and spores in the anther and elsewhere, we must be prepared to examine the detailed evidence which establishes that the embryo-sac is a spore, comparable to the pollen-grain which is also a spore, as we have seen. And the embryo-sac being a spore, the nucellus in which it is developed is a sporangium, and the processes leading to the development of the more or less rudimentary tissues inside the spore—endosperm, archegonium, and oosphere in Gymnosperms, and egg-apparatus, antipodal cells, &c., in Angiosperms—are comparable to the processes leading to the development of the much more rudimentary tissues in the germinating pollen-grain. In other words the process is that of the germination of the spore *in situ*.

CHAPTER XIV.

FLORAL DIAGRAMS AND FLORAL FORMULÆ.

Plan Diagrams of Buds—Floral Diagrams—Median, Lateral, and Oblique Planes of Symmetry—Cyclic flower—Regular and Actinomorphic—Irregular and Zygomorphic—Monosymmetrical, Isobilateral, &c.—Asymmetry—Empirical and Theoretical Diagrams—Selected Types—Conventional letters and signs—Floral Formulæ—Examples—Buttercups—Laburnum—Bittersweet—Ericaceæ—Ob-diplostemony—Polymorphic flowers—Cleistogamy—Heterostylism—Polygamy, &c.

It was shown in Volume I. pp. 41—48, that much information regarding the relations between the parts of a bud can be expressed in the form of plan diagrams, based on transverse sections and comparative dissections of the buds themselves, together with facts derived from considerations of their development and alliances.

Just as in the case of leaf-buds so with those of the flower, it is possible to show very clearly on either actual or theoretical diagrams many of the most important facts of structure. Such diagrams are here termed *floral diagrams*, and the art of constructing them has been carried to great perfection, because the essential structural arrangements in the flower frequently correspond in large groups of plants; the systematic classification of plants being, in fact, based chiefly on these very resemblances and differences.

It may be noted that the flower, since it usually opens out without elongating, and, unlike a bud, usually spreads its parts, so that the observer can look down upon it, lends itself far more readily to the plotting of a plan; consequently sections are rarely required, though they also have their uses and interest.

If we regard from the front a lateral flower on a vertical stalk, and agree to call the longitudinal planes bisecting the flower as follows—that passing vertically through the flower and its stalk *median*, that at right angles to this *lateral*, and any which is oblique to these *oblique*—we obtain three planes of symmetry of the flower which can be made use of in descriptions in various ways.

We have seen that the parts of an ordinary flower are arranged round the floral axis, and some considerations of importance occur in connection with the manner of this arrangement.

In a Lily, for example, we find three outer and three inner similar segments of the perianth followed by three outer and three inner stamens, and a gynœcium of three carpels: that is to say, five whorls, in each of which the three organs are similar in shape, size, texture, &c. Moreover in each whorl or *cycle* the organs alternate with those of the next whorl. Such a flower is cyclic (in this case *pentacyclic*) with respect to the number of whorls, and *regular* in regard to the symmetrically radial arrangement of its parts: moreover, if we cut it vertically in half with a sharp razor it will be found that it can be so bisected in three planes, passing in each case through the middle of a carpel, two stamens, and a sepal and petal respectively, that each half is the mirror reflex of the other. There are, in other words, three planes of symmetry in this flower. In a Geranium, *Primula* (Fig. 29), &c., there are five planes of symmetry in which the flower

may be thus cut into similar halves, and in some species of *Sempervivum* as many as a dozen or more such planes.

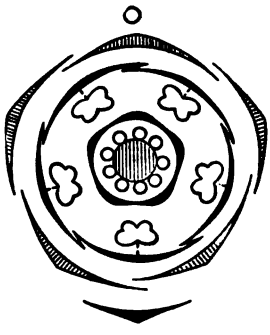


Fig. 29. Floral diagram of *Primula acaulis*. It is regular and actinomorphic: similar halves are obtained by a vertical section passing through the middle line of any sepal (Ei).

In these cases the flower is more than merely regular—a word which simply signifies that the parts of each whorl are similar to each other in appearance and are regularly arranged round the floral axis—for they are also *actinomorphic*, i.e. radiately arranged so that the flower can be cut into similar halves through more than two planes of symmetry.

In contrast to these cases we may examine the *irregular* flower of a Pea. Here it is clear we can only cut the whole flower into two similar halves by a vertical cut passing through the large posterior petal (standard) and the keel: in any other than this median vertical plane the section results in two dissimilar halves. The flower is *monosymmetrical* and *zygomorphic*. The same is true of *Linaria* and *Veronica* (Fig. 30, *B*, *C*).

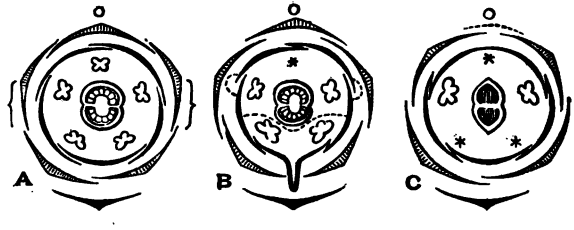


Fig. 30. Floral diagrams of *A*, *Verbascum nigrum*; *B*, *Linaria vulgaris*; *C*, *Veronica Chamædrys* (Ei).

In descriptive field-botany it is usually regarded as sufficient to say whether the flower is regular or irregular, but observation brings out that there are several types of each. Thus, the flowers of a Crucifer (Fig. 31), a Fuchsia, a six-petalled *Sedum*, and a Gentian are all regular, but the Crucifer is also *isobilateral*; it can be divided into symmetrical halves in two planes at right-angles, but the halves in one plane are unlike those in the other. In the cases of the Fuchsia and the six-petalled *Sedum*, there are four and twelve planes respectively, half giving similar halves of one kind, and half giving those of the other kind, and these instances can easily be multiplied by the student. In the Gentian only one plane can be found in which perfectly similar sections result, because there are only two carpels; but although it may be argued that such a flower is strictly not actinomorphic but zygomorphic, no field-botanist would term it irregular.

Fig. 31. Floral diagram of a Crucifer. The flower is regular, but isobilateral (Ei).

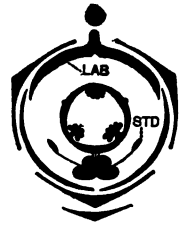


Fig. 32. Floral diagram of *Orchis*, before resupination. LAB. = labellum, STD. = staminode (Ei).

In similar manner, when we come to irregular flowers, several cases occur in addition to the one described. The flower of *Dicentra* is irregular, but bilateral: that of a *Valerian* or *Canna* is asymmetric, in so far that there is

no plane in which it can be cut into two symmetrical halves.

These examples will suffice to show that the terms regular and irregular refer merely to the similarity or otherwise between the parts of each whorl, whereas the more modern terms actinomorphic, zygomorphic, and asymmetric refer to the planes of symmetry of the flower.

On looking down into a flower it is usually possible to directly observe the plan of arrangement of the parts, and it is often convenient to adopt a consistent system of signs and diagrams to represent this.

If we project the spiral line joining the insertions of the successive organs in the terminal flower of a Barberry (Fig. 17), for instance, and mark on it at the relatively proper distances the organs themselves—which may be conveniently done by diagrammatic sections of each sepal, petal, stamen, and carpel—a conventional figure known as a *floral diagram* is obtained, such as those shown in the accompanying illustrations.

Obviously the *empirical* diagram, representing merely the projection into one plane of what is actually visible in an open flower, may be added to by indicating organs, relations in space, displacements, &c., not directly observable in the field but inferred from comparisons with other flowers and from the study of development, &c., and so converted into a *theoretical* diagram.

For instance the floral diagram of a *Veronica* (Fig. 30, *C*) shows only two stamens, but that of most Scrophulariaceæ has four (Fig. 30, *B*), and since some have five (Fig. 30, *A*), and several exhibit a rudimentary outgrowth in the position of the fifth stamen, there is evidence for regarding the theoretical diagram of *Veronica* as retaining two perfect stamens and as having lost three,

and this evidence is strengthened by further comparisons of allied forms; similarly with the corolla—only four sepals and four petals are visible, but theoretically there are five of each.

Theoretical floral diagrams are of undoubted value in morphological studies pursued with a requisite knowledge of the actual existing state of affairs in living plants, but the tendency in some modern text-books to place large series of them before elementary students may easily lead to confusion and misapprehensions.

In order to aid in the practice of actually making floral diagrams, however, the reader may compare the following examples with the flowers they represent:

Willow, Wallflower, Blackberry, Rose, Pear, Ivy, Elder, *Verbascum, Linaria, Veronica, Primula, Orchis* (Fig. 32), *Ranunculus,* (Fig. 33).

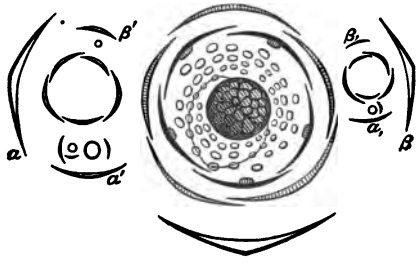


Fig. 33. Inflorescence (axillary dichasial cyme) of *Ranunculus acris* with details of central flower showing spiral arrangement. Stamens in $\frac{\infty}{2/1}$ phyllotaxy. α, β, bracteoles of central flower, in the axil of each of which arises a lateral flower with bracteoles α', β'; branching is repeated in the axils of α', β' (Ei).

The exigencies of descriptive botany have also called forth another way of expressing shortly such structural arrangements in a kind of shorthand, so to speak.

If we agree to accept the conventional letters *K, C,*

A, and *G* as expressing the Calyx (sepals), Corolla (petals), Androecium (stamens), and Gynœcium (carpels), respectively, it is easy to denote, by certain numbers and signs in sequence, the relations of number and position of the parts in any flower, thus :—

$$K_3\ C_3\ A_3\ G_3$$

would signify that the given flower consists of four whorls of three organs each; i.e. three sepals (K_3), three petals (C_3), three stamens (A_3), and three carpels (G_3), and if we agree that when written as above the mere numerals denote that each whorl of organs alternates with the organs of the next whorl and that each organ is separately inserted, the *floral formula* sums up a good deal of information in a very compact form. But we may also agree that, written as above, the flower is actinomorphic, because nothing to the contrary is indicated; and, for the same reason, that, just as the sepals, petals, and stamens are free, so are the carpels. Further we may assume—nothing to the contrary being expressed—that the ovary G_3 is superior.

Supposing our flower to be as above, but to have two whorls of three free stamens each, and that the ovary is syncarpous, as in a Lily. Then the floral formula would run :—

$$K_3\ C_3\ A_{3+3}\ G_{(3)},$$

the additional whorl of stamens being expressed by + 3, and the syncarpy of the ovary by the ( ) enclosing the number.

Now suppose that, all else remaining as before, the ovary is inferior—e.g. in an Amaryllis: the formula would then run :—

$$K_3\ C_3\ A_{3+3}\ G_{\overline{(3)}}$$

the stroke — *above* the number attached to the sign *G* (*Gynœcium*) signifying that the latter is inferior.

In cases where the calyx (K) and corolla (C) cannot be distinguished, we can use the letter P to denote *Perianth*, and the formula

$$P_3\ A_{3+3}\ G_{(3)},$$

for instance, would indicate that our flower had a perianth of three separate parts, six stamens in two alternating whorls of three each, alternating with these parts and with the three united carpels of a superior syncarpous pistil.

But suppose some of the organs were too numerous to be worth recording: the sign ∞ for indefinite would then indicate this as follows:—

$$K_5\ C_5\ A_\infty\ G_\infty,$$

which would show that our flower—e.g. a Buttercup (Fig. 33)—had a calyx of five free sepals, a corolla of five free petals, an androecium of an indefinite number of free stamens, and a pistil composed of numerous free carpels.

If we now take the case of a flower such as that of a Laburnum, several points of difference from the above appear. Its calyx is gamosepalous, its corolla is zygomorphic, its ten stamens are joined in a tube, and it has but one free carpel. All this is easily expressed in the floral formula as follows:—

$$K_{(5)}\ \downarrow C_5\ A_{(5+5)}\ G\,1,$$

the ( ) indicating the gamosepaly of the calyx, and the concrescence of the stamens; the $\downarrow$ indicating that the corolla is zygomorphic in the median plane; and the $G\,1$, that there is but one free carpel.

Similarly the floral formula of the Bittersweet

$$K_{(5)}\ \underbrace{C_{(5)}\ A_5}\ G(2)$$

indicates by the linking $\smile\!\frown$ that the stamens are inserted on the corolla.

If, as occurs in the Ericaceæ for instance, the actual number of organs in each whorl varies in the different genera, but the relative numbers are constant in the flower, we can use a general floral formula thus:—

$$K_{(n)}\ C_{(n)}\ |\ A_{n+n}\ G\,(n)$$

and add the values attached to n, in this case 4 or 5.

The formula given still tells us that the flower is actinomorphic, the calyx and corolla gamophyllous and equally segmented, the stamens twice the number of these segments, and free from the corolla, and the pistil has the same number of carpels and is superior.

Theoretical considerations show that such a flower has the stamens displaced from the strictly alternate position, and this *ob-diplostemonous* condition is denoted by the sign | which signifies that the outermost whorl of stamens is opposite the petals, or rather, here, the corolla lobes.

Many other signs can of course be employed, but enough has been said to explain the principles. It not unfrequently happens that while most of the flowers are of one kind and order of symmetry, terminal ones in an inflorescence are different, as in the Rue, where most of the flowers are $4\sqrt{}$ but the end one $5\sqrt{}$; *Adoxa*, with the terminal one $4\sqrt{}$ and the lateral ones $5\sqrt{}$, and other cases occur. In *Acalypha indica* the single ♀ flower which terminates the mixed inflorescence has only one ovule, and that unlike those of the other ♀ flowers. In the Sycamore and other species of *Acer*, flowers with various numbers are common in the inflorescence, and while the lateral flowers are usually ♂ the terminal are ☿. The central flower of the umbel of *Daucus carota*, the wild carrot, is purple, the others white. Many other cases of polymorphy of the flower are known. The terminal flower of an inflorescence with zygomorphic flowers is not

unfrequently actinomorphic, and such cases, coupled with the fact that all the flowers of a species normally zygomorphic occasionally become actinomorphic (e.g. *Linaria*), help us to infer that actinomorphy was the primitive state.

Again, many plants, *Viola, Oxalis, Lamium amplexicaule, Salvia verbenacea,* &c., bear cleistogamic flowers in addition to the normal one, and there are reasons for concluding that nutrition affects these matters, as also cases where some flowers of a plant, which normally produces typical ☿ flowers, may be habitually deficient in the pistil or stamens and so be rendered more or less imperfect by abortion. All such phenomena suggest that the flower is still to a certain extent a plastic mechanism, and we may conclude that natural selection has rendered some of these polymorphic states more or less fixed, because they have proved of advantage to the species in cross-fertilisation—e.g. the heterostyled flowers of *Primula, Lythrum, Oxalis, Linum, Erythroxylon, Hottonia, Pulmonaria, Bouvardia, Mitchella, Fagopyrum, Pontederia,* Statice, *Menyanthes,* &c.; the gynodiœcious flowers of *Thymus, Nepeta,* Alsineæ, *Scabiosa, Plantago,* &c.; the gynœmonœcious flowers of Compositæ, &c.; and the andromonœcious and androdiœcious flowers of *Veratrum* and *Dryas* respectively; as well as the polygamous flowers so common in species of *Fraxinus, Rhus, Rhamnus, Parietaria,* and many other plants.

It must not be supposed that floral diagrams and floral formulæ are confined in their application to the higher flowering plants. As reference to the following examples, Figs. 34 and 35, will show, they are especially useful in elucidating the structures of the inflorescences and minute inconspicuous flowers, met with in most of our forest trees and shrubs. Eichler worked out the theoretical

diagrams of these with telling effect, introducing system and order into these difficult cases.

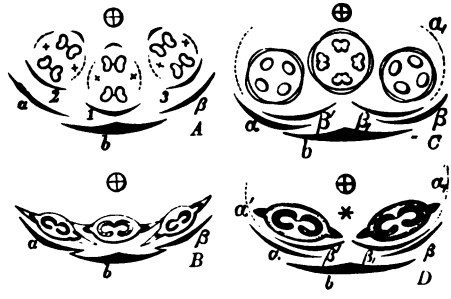


Fig. 34. *A*, plan diagrams of a ♂, and *B* of a ♀ inflorescence of the Birch; *C* and *D*, of ♂ and ♀ inflorescences respectively of the Alder. In each case the catkin-scale *b* has a small dichasium of three flowers (the central one * absent in *D*, however) in its axil. The flowers of the dichasium, of which the central is the oldest, are subtended by bracts α and β and bracteoles α' and β'. It is these bracts which join the catkin-scales and give them their compound character (Ei).

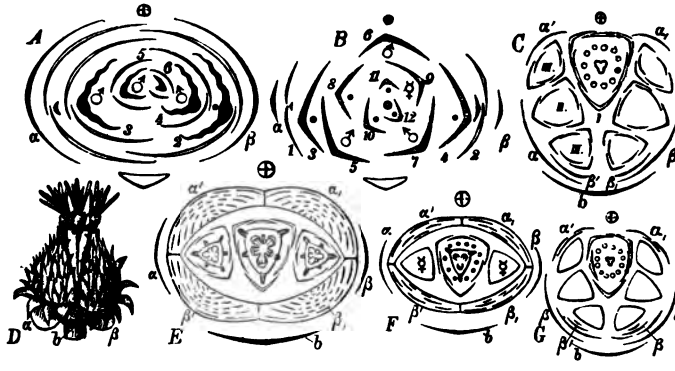


Fig. 35. Plan diagrams of Chestnut. *A*, of a ♂ lateral shoot with distichous leaves; *B*, of a shoot with spirally arranged leaves and bearing both ♂ and ♀ partial inflorescences; *C*, of a ♂ partial inflorescence, showing stamens and rudiment of pistil in the primary flower only. *D*, a ♀

partial inflorescence twice natural size; and *E*, diagram of the same, showing *b* the bract subtending it and ⊕ the axis of the spike of which *b* is a scale; *α* and *β* bracts to right and left of the three-flowered partial inflorescence (*dichasium*); *α'* and *β'* the cupule, investing the three ♀ flowers each of which has its six-partite perigone and six-chambered ovary. *F* and *G*, cases of transition between *E* and *C*, where flowers with both stamens and pistil occur; all three flowers may be ♂, or the middle one ♀. In all cases *b* is the cover-scale of the spike or catkin, in the axil of which the dichasium stands; *α* and *β* are the lateral subtending bracts of the dichasium; *α'* and *β'* probably correspond to the bracteoles of the flowers as in Fig. *E*, though here they form the cupule (Ei).

We thus see that a great deal of theory can be expressed in these floral diagrams, as it could in the plan diagrams of buds described in Volume I., in both cases the additional information being derived from comparative morphology and from the study of development.

It is not necessary to give further examples here, since the cases concerned will be found fully illustrated in Part II.

CHAPTER XV.

TYPES OF FLOWER.

Simplest types—Yew—Juniper and Cypress—Pine, Fir, Larch and Cedar—Cones—Gymnospermy—Angiosperms—Willows and Poplars—Achlamydeous Flowers—Unisexual Flowers—Birch, Alder and other Catkinate Trees—Chestnut—Husk or Cupule—Oak, Beech, &c.—More highly specialised Flowers—Hypogynous Flower of Buttercup and Clematis—Discifloral Flower of Maple—Disc—Rosaceous Type—Passage from perigyny to epigyny—Leguminous and Papilionaceous Type—Gamosepaly and Zygomorphy—Ericaceous Type—Gamopetaly—Caprifolicious Type—Epigyny, &c.

It will now be advisable to fix our ideas, fortified with the preceding details, on the structure, symmetry, and comparative morphology of the flower and its parts, by describing certain selected types of flower such as are illustrated by the trees and shrubs here to be dealt with.

One of the simplest of all flowers is that of the Yew. On some of the Yew-plants we find the flower consists simply of a short axis bearing about three decussate pairs of opposite scales and terminating in an ovule, which is completely exposed (naked) except for a loosely investing fleshy cup, known as the *aril* (Figs. 28 and 46). Here then we have the flower reduced to its simplest possible elements; a single ovule, with a few investing scales. It looks so like an ordinary green bud at the time of flowering that

some observation is needed to detect the tip of the ovule protruding above.

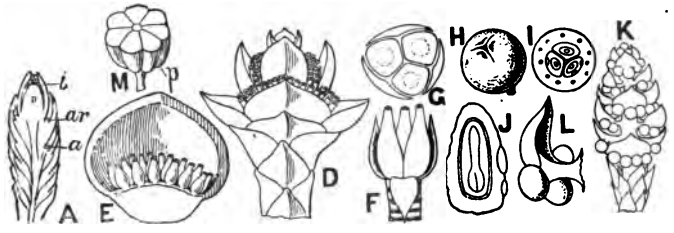


Fig. 36. Types of gymnospermous flowers. *A*, a ♀ flower of the Yew in vertical section; *a* apex of the main axis, of which the flower is an axillary shoot; *ar* arillus; *i* integument; *n* nucellus (cf. Fig. 28, p. 120); *M*, a stamen; *p* pollen-sacs; *D*, a ♀ cone of Cypress; *E*, one of its scales subtending numerous erect ovules; *F*, dissected ♀ cone of Juniper, showing three erect ovules subtended by scales; *G*, the same in transverse section; *H*, ripe "berry"; *J*, seed in section; *K*, a ♂ cone of Juniper; *L*, a stamen (Re).

Other plants of the Yew bear the male flowers, each of which again consists of a short axis bearing about 6—14 scale-like appendages (stamens), each shaped like a small mushroom or umbrella, attached to the axis by the "handle," and bearing 6—8 pollen-sacs on its under surface—i.e. on the surface turned to the axis (Fig. 36, *M*). Below these the axis bears 6—7 pairs of decussating flat membranous scales, gradually increasing in size from below, the uppermost pair being delicate and whitish and about 3 mm. long.

So that here again we have the flower reduced to a few stamens, subtended below by a few enveloping scales. In neither the male nor the female flower can we speak of a perianth, though possibly the scales immediately surrounding the base of the ovule or the cluster of stamens, respectively, may be regarded as the foreshadowing of such.

In the Junipers and Cypresses, Pines, Larches, Firs and Cedars, we find flowers hardly more advanced than the above, excepting that the cones—as the flowers are here termed—bear more scales on the floral axis.

In the Juniper, for instance, the bud-like female flower consists of a short axis bearing about 6—8 alternating whorls of three leaves each. In the axil of each of the uppermost scales, and displaced to the right, is an erect ovule: in other words a single whorl of three erect ovules alternates with the three upper scales (Fig. 36).

In *Cupressus* we have a similar state of affairs, except that the scales are opposite and decussate, and about 8—14 of the upper more or less peltate scales bear numerous erect ovules in the axil (Fig. 36).

In both the Juniper and the Cypress the male cone (flower) consists of similar whorls or decussate pairs of scales bearing a few pollen-sacs below.

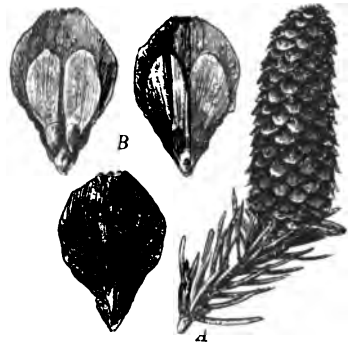


Fig. 37. *A*, a ♀ flower (cone) of the Spruce. *B*, scales seen from above and showing the placental scales with ovules, and from below (Wi).

In the ordinary Conifers—Pines, Firs, Larch, Cedar, &c.—the state of affairs is slightly more complicated in

so far that the male cone (flower) consists of numerous spirally arranged scales of which all but the lowermost bear two pollen-sacs each on their lower faces; while the female flower (cone) has similarly numerous spirally imbricated scales, each of which, except the lowermost, bears on its axillary face a second appressed scale, on the upper face of which are two collateral ovules in an inverted position—i.e. the apex, or micropyle end, of each ovule is turned towards the axil (Figs. 37, 38).

Many views have been taken as to the morphology of the cone. I shall adopt the simple, and widely accepted one, that each scale represents an open carpel, bearing

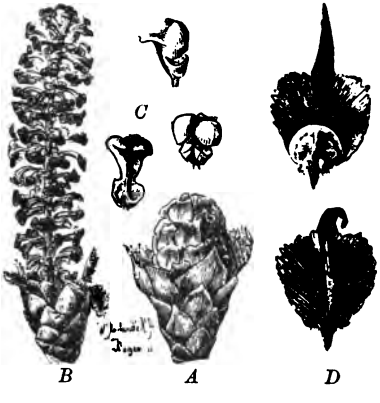


Fig. 38. Flowers of the Silver Fir. *A*, young, and *B*, old staminate cone, consisting of numerous staminate scales on an axis, with imbricated barren scales below; *C*, three stamens seen from above, from below, and from the side. *D*, scales of ♀ cone seen from below and from above, the latter showing the placental scales and its two ovules (Wi).

on its inner (upper) face a placental scale bearing two inverted ovules. Whether the barren scales at the base of the cone represent incipient floral envelopes or not is hardly important, but it is significant that they are

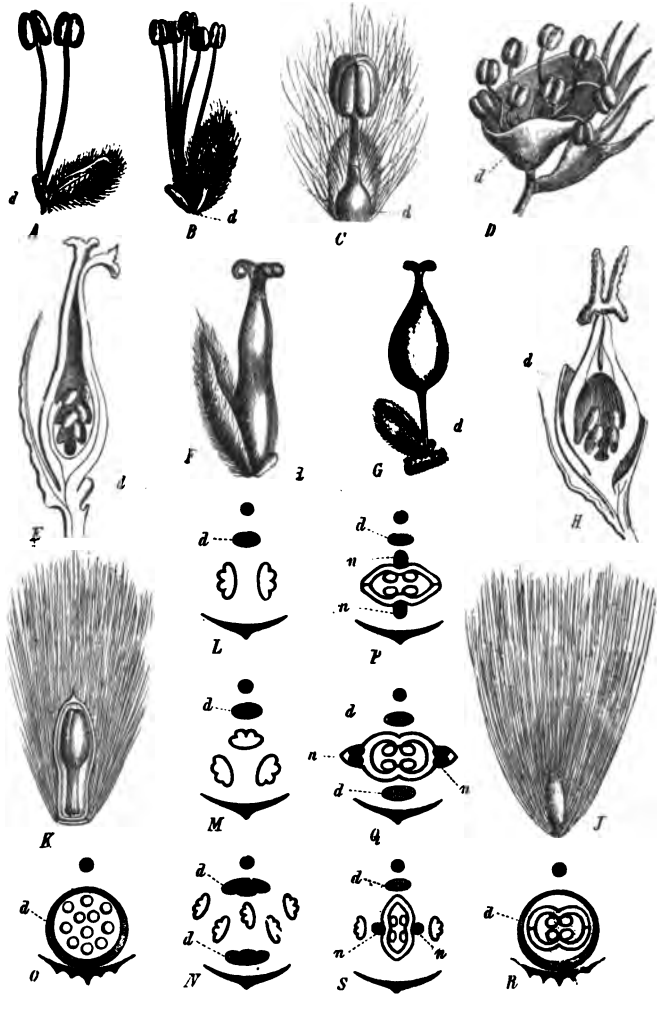


Fig. 39. Flowers of Willows and Poplars. *A*, male flower of *Salix fragilis*; *B*, of *S. pentandra*; *C*, of *S. purpurea*; *D*, of *Populus tremula*.

E, female flower of *S. alba* in longitudinal section; *F*, female flower of *S. pentandra*; *G*, of *S. tetrasperma*; *H*, of *Populus tremula* in section. *J*, seed of *Populus*; *K*, of *Salix* in longitudinal section. *L*, floral diagram of male flower of *S. Caprea*; *M*, of *S. triandra*; *N*, of *S. pentandra*; *O*, of *Populus tremula*. *P*, diagram of female flower of *S. Caprea*; *Q*, of *S. alba*; *R*, of *Populus*. *S*, diagram of hermaphrodite flower of *S. Caprea*. In all cases *n* indicates stigma; *d* the disc or glands (E and P).

often larger, differently shaped, and even more delicate in texture and colour than the carpellary scales above.

In all the foregoing cases we see that the extreme simplicity of the flower is expressed in three peculiarities.

In the first place, the very simple nature of the floral organs: there is no definite perianth, and each flower consists of either a few or many stamens, or of one or more ovules, with or without carpellary scales.

Secondly, the carpellary or staminal scales are mere scales, and not differentiated far from the structure of other scales or scale-like leaves on the plant.

In a third peculiarity we have something totally different from the normal state of affairs in a typical flower—viz. the ovules are not covered in a closed ovary: the carpellary scale, when it exists, does not fold over the ovule or ovules, and thus the latter are naked, or exposed, a feature of fundamental importance, and which Robert Brown, in 1827, emphasized by calling these plants *Gymnosperms*, or naked-seeded plants with open carpels.

But even in flowers of the higher series of seed-plants, called *Angiosperms* because their ovules are always enclosed in a box-like covering formed of closed carpels—the ovary or pistil—we find very simple flowers among the lower members of the group.

Among the simplest are the flowers of the Willows and Poplars.

If we dissect off carefully one of the scales of a female

catkin of a Willow, we find in its axil a single more or less flask-shaped ovary, stalked or sessile, subtended by one or two minute, yellow, club-shaped bodies termed honey-glands, as in Fig. 39.

There is nothing to which we can give the name of petals or sepals, and no stamens are present in this normal female flower: it is *achlamydeous* and *unisexual.*

Simple as it is, however, the fact of there being a developed closed ovary, formed of two carpels, as betrayed by the double stigma and the two parietal placentæ, bearing several ovules, stamps this as a more highly differentiated flower than that of any Conifer.

And similarly with the male flowers: each scale of a male catkin of the Willow bears in its axil two (or in rare cases 1, 3, or 5) stamens subtended by one or two minute honey-glands as before, and the differentiation of the stamen into a filament and anther marks the flower —simple as it is—as more highly specialised than the male flower of the Gymnosperm. The flowers of the Poplar are similarly simple, with a few differences in details concerning the shape, &c., of the glands and the numbers of the stamens, as shown in Fig. 39.

Here, again, we have flowers of extremely simple structure, and unisexual and achlamydeous.

Let us take as a further example the Birch.

On dissecting off the scale of a female catkin we here find, instead of the simple bract of the Willow with one axillary flower, a complex of one larger median bract (*b* in Fig. 40) bearing two lateral bracteoles (*α* and *β*, Fig. 40) on its inner face, and each of these subtends an ovary: there is no perianth.

Here, then, the principal catkin-scale bears in its axil a small inflorescence of three achlamydeous and unisexual

flowers—really a dichasium, since the median flower opens first.

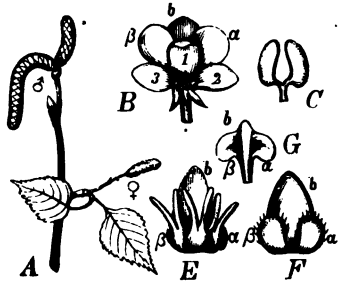


Fig. 40. Flowers of the Birch. *A*, shoot bearing ♂ and ♀ catkins. *B*, catkin-scale *b*, with bracteoles *a* and *β*, and perianth scales 1, 2 and 3, of a ♂ partial inflorescence seen from above, and the stamens not indicated (cf. Fig. 34). *C*, a stamen. *E*, a catkin-scale seen from above, bearing in its axil two bracteoles, *a* and *β*, which subtend the three ♀ flowers. *F*, the same after dissecting off the flowers. *G*, the same after ripening (cf. Fig. 34); the two bracts *a* and *β* adhering to the scale (Ei).

On similarly dissecting off the scale of a male catkin, we find it also bears two lateral adherent bracteoles (*a* and *β* in Fig. 40, *B*) and each subtends a male flower of four stamens surrounded at the base by a rudimentary perianth of two to four minute scales, or, sometimes, only of one scale.

The Birch, then, shows us an example of a catkin of small clusters (dichasia) of flowers little more differentiated than those of the Willow, but the males at least with a very simple perianth.

Many similar cases will be found in other members of the catkin-bearing trees, e.g. Alder, Hazel, Hornbeam, Beech, Chestnut, Oak, &c., with gradual advance in complexity.

I select one more illustration of such types.

The flowers of the Chestnut (*Castanea*) are green and inconspicuous, as in the cases cited above, but are clustered on stiff spikes. On some of these we find the whole of the upper parts occupied by axillary clusters of male flowers, a few clusters of female flowers occupying the very base (Fig. 41).

Fig. 41. 1, flowering shoot of Chestnut, showing a spicate inflorescence bearing clusters of ♀ flowers below and of ♂ flowers above. 2, section through a cluster (dichasium) of ♀ flowers; 3, transverse section of ovary; 4, a ♂ flower; 5, fruit in the dehiscing cupule (Wo).

On removing one of the upper bracts, with its axillary cluster of male flowers, we find that the bract (*b* in Fig. 35, *C*) bears in its axil bracts (*a* and *β*) and several

bracteoles ($aa'\beta\beta'$ in Fig. 35, *C*) subtending as many as seven male flowers, each composed of a six-lobed bell-shaped perianth containing about a dozen stamens, and often with a central rudiment of an aborted ovary. Close investigation shows that we have here a cymose cluster of male flowers, in the axil of the bract.

Similar dissection of a cluster of female flowers (Fig. 35, *E*) shows that the bract bears in its axil a group of three female flowers, surrounded by a common thick investment somewhat prickly on its outer sides, and subtended below by two lateral bracts (a and β in Fig. 35).

Each female flower shows a flask-shaped ovary, chambered into about six loculi and bearing above the same number of stigmatic arms. Around the base of the stigmas there are also an equal number of sepal-like segments, constituting an epigynous perianth: i.e. the ovary is inferior. There are no stamens in the normal case (Fig. 41).

Here then we have a cluster—dichasium—of three female flowers with an epigynous perianth. Consequently the investing prickly structure cannot be the perianth: what is it?

The comparative morphology of numerous other cases shows that we must regard it as a special investment of the inflorescence, and it is termed the *Cupule*. It is essentially the same organ as occurs in the Hornbeam as a leafy trilobed, bract-like structure investing the fruit, and as the "Husk" of the Filbert, and the "Cup" of the Acorn; the cupule of the Beech invests two flowers, that of the Oak one. Further particulars will be found in each case in Part II. The essential points to notice here are, the increasing complexity of the catkins and of the investing structures, and the epigyny of the female flowers.

So far I have selected for our types flowers of simple structure and—as compared with the more perfectly differentiated flowers of the Buttercup, Rose, Laburnum, Honeysuckle, &c.—of imperfect composition.

We will now examine one or two examples of the more highly specialised floral types, so well known owing to the æsthetic beauty of their coloured or conspicuous perianth or corolla.

The Buttercup, already described on p. 129, affords us an excellent example of a complete actinomorphic, polypetalous flower, with hypogynous stamens and corolla, and apocarpous pistil; and the stamens and carpels at least are spirally arranged—acyclic. Its floral formula runs as follows:—

$$K_5\ C_5\ A_\infty\ G_\infty.$$

The Clematis affords another example of the same type, with the difference that it has only one whorl of petal-like non-essential organs. This *perianth* is really a calyx; there is no true corolla developed.

The flowers of the Sycamore (Fig. 42) and Maples, *Aceraceæ*, afford us examples of a new structure, interposed as a fleshy ring-like cushion or wall of tissue around the floral axis at the base of the calyx, and between it and the stamens: this ring of tissue is known as the disc, and many authors separate off the Natural Orders bearing such a disc in their flowers from the Thalamifloræ, as the Disciflorae. We may term it the Discifloral type.

Careful examination of a flower of the *Sycamore* shows that while the calyx of five separate sepals, and the corolla of five separate petals alternating with them are actinomorphic, the stamens are only eight in number, the posterior one and the anterior one being absent; and the ovary consists of two carpels only placed anteroposteriorly, and consequently the androecium and pistil

are zygomorphic in the median plane. In some of the flowers, however, this plane of zygomorphy may be oblique.

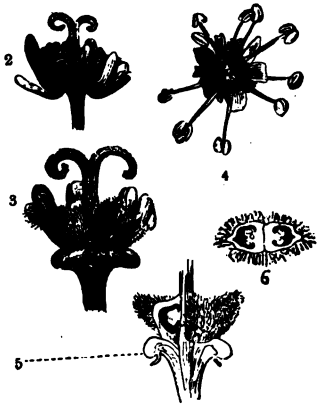


Fig. 42. Flower of the Sycamore, showing, 2, complete flower; 3, the same after removal of petals and sepals, the stamens arising from the fleshy disc; 4, staminate flower seen from above; 5, ovary with the hypogynous disc; 6, ovary in transverse section (Wi).

The typical floral formula is therefore:—

$$K_5\ C_5\ A_{4+4}\ \underline{G(2)}$$

with median or oblique symmetry of the androecium and pistil.

A well-marked type is the Rosaceous flower, characteristic, as its name denotes, of the large family Rosaceæ —to which the Roses, Blackberry, Raspberry, Apple, Pear, Hawthorn, Rowan, Service-tree and other species of *Pyrus*, and the Cherry, Plum, and other species of *Prunus* belong (Fig. 43).

The Rosaceous flower has a more or less well-defined calyx-tube, or hollowed receptacle, which may be shallow

and spreading open, like a saucer, as in *Rubus* (Fig. 43, *B*), or deeper and more cup-like, as in *Prunus* (Fig. 43, *A*), or more prolonged upwards and tending to close in above, somewhat like an urn, as in *Rosa* (Fig. 43, *C*), or even narrowed to a small orifice closely investing the style or styles above, as in *Pyrus* (Fig. 43, *D*—*F*).

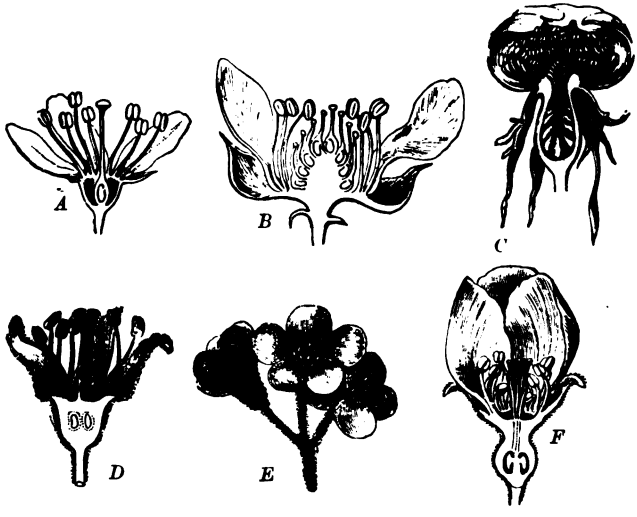


Fig. 43. Rosaceous flowers. *A* Blackthorn, *B* Blackberry, *C* Rose; all these are perigynous. *D* and *E* White Bean, *F* Pear; all epigynous.

At the margins, or throat, of this calyx-tube the sepals come off as five equal and more or less separate and triangular or ovate lobes, spreading or reflexed as the flower opens, but fitting together at the slightly imbricate margins in such a manner that two sepals overlap their neighbours with both margins, two underlap with both margins, and one has its upper margin overlapping and its lower underlapping, a kind of æstivation known as

quincuncial. In many cases the imbrication is so slight, however, that the margins must be regarded as merely in contact (*valvate*).

Then follow five equal petals, alternating with the sepals and inserted just inside them, with even more pronounced quincuncial æstivation, and spreading as the flower opens as five delicate white or pink, more or less obovate, and usually large and conspicuous organs, the odd one being the anterior and with its one edge covered and its other overlapping.

Close inside the petals come numerous, about twenty, stamens, curved inwards in the bud.

Inserted at the base of the calyx-tube are the carpels, which may be one (*Prunus*), or two to five (*Cratægus*, *Rosa*, *Pyrus*), or many (*Rubus*), and it is chiefly in the numbers, degree of coherence, behaviour during ripening of the carpels, and in certain relations of the carpels as a whole to the calyx-tube, that these otherwise very similar Rosaceous flowers differ among themselves.

For instance, in *Prunus* (Fig. 43, *A*) the one carpel becomes the single fleshy cherry, plum, &c., growing quite beyond the calyx-tube as it ripens.

In *Rubus* the numerous carpels develope into the numerous small fleshy pips—each like a small cherry in structure—raised on the dome-like central part of the floral axis, and again growing out beyond the calyx-tube (Fig. 43, *B*).

So that in both *Prunus* and *Rubus* we find the remains of the sepals, petals and stamens at the base of the fruit, owing to the growth of the latter beyond them. In the flower, however, these organs are *perigynous.*

In the Rose the carpels are inserted at the base of the urn-shaped calyx-tube, and ripen to dry achenes, only the long styles of which project at the top. Here the calyx-

tube has carried up the sepals, petals and stamens to a level which overtops the carpels—in position they are therefore *epigynous*—but the latter remain free and do not adhere to the calyx-tube.

In the Apple, Pear and their allies, we have a condition of affairs very similar to the last, but the flower has now become truly epigynous, the insertion of the sepals, petals and stamens being brought right on to the top of the structure, and the carpels fuse more or less one with another and with the walls of the calyx-tube.

Thus the Rosaceous type of flower may be shortly characterised as regular (*actinomorphic*) with a calyx-tube bearing five sepals, five free alternate petals, and numerous stamens, and one to five or more carpels either apocarpous and nearly superior, or syncarpous and more or less inferior. The general floral formula is

$$K_5\ C_5\ A\ \infty\ G\ 1—\infty\ [\text{or } (\overline{2—\infty})]$$

and the fleshy portion of the "fruit" may be formed from the true carpels (*Prunus*, *Rubus*, &c.), or from the calyx-tube (*Rosa*, *Pyrus*, &c.). There are other variations in the "fruits" of Rosaceous plants not here concerned.

Another well-marked type of flower is that met with in the great Natural Order Leguminosæ, and especially characteristic of the Papilionaceæ, the only division of the order which concerns us: it is termed the papilionaceous flower, because older observers compared it with a butterfly. Any flower of a Laburnum, Robinia, Gorse, Whin, Broom, Petty Whin, &c., illustrates the type.

A more or less tubular or cup-shaped calyx is cut at its margins into five equal or unequal sepaline teeth or lobes, and is therefore *gamosepalous*.

On the inner face of this, near its base, are inserted

five free petals and ten stamens, so that these organs are *perigynous*, since they do not spring from the axis.

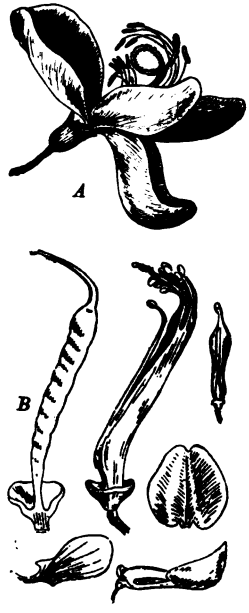


Fig. 44. Papilionaceous flowers. *A*, complete flower of Broom; *B*, flower of Robinia dissected to show the ovary, the ovary enclosed in the staminal tube, and the standard, wings and keel.

From the base of the calyx-tube arises one carpel, which ripens into the well-known pod or *legume*, which gives the name to the order—*Leguminosæ*.

The petals are strikingly characteristic in both form and arrangement: they are never alike in shape or size in the plants here concerned, and their manner of folding in the bud (*æstivation*) is constantly as follows.

There is one large posterior, or upper, petal which

stands up more or less, and is termed the standard (*Vexillum*): in the bud this is folded together with its margins directed downwards and covering all the other petals.

Then come two narrower petals, one on each side and pointing forwards, termed the wings (*Alæ*); and these cover with their lower margins the two lowermost petals in the bud, their upper margins being overlapped by the lower margins of the folded standard.

Finally there are two narrow petals, each shaped somewhat like the sides of a boat cut vertically along its longitudinal axis, and since these two petals fit edge to edge—as if the bisected boat were reconstructed by bringing together its two halves—they form what is known as the keel (*Carina*): in the bud these two opposed carinal petals have their upper margins overlapped by the wings.

The separate insertions of these five unequal petals alternate with the sepals.

Just inside the petals come the ten stamens, and it is a curious fact that in all the cases here concerned the filaments are conjoined into a tube surrounding the ovary: in *Ulex*, *Genista* and *Cytisus* this tube is complete, but in *Robinia* the tenth (posterior) stamen stands alone, the other nine forming the tube.

The ovary is formed of a single carpel, the apex of which is prolonged into a style.

The Leguminous type of flower is thus seen to be pentamerous and diplostemonous, zygomorphic in the median plane, with a gamosepalous calyx, perigynous free petals, and mon- or di-adelphous stamens, and a single free-carpel ripening to a pod.

This may be expressed in a floral formula as follows:

$$\downarrow K(5)\ C5,\ A\ \underbrace{5+5}\ [\text{or}\ \underbrace{5+4}+1]\ G1.$$

Another distinct type is that of the Natural Order Ericaceæ, comprising the Heaths, Ling, Strawberry-tree, Bilberry, Cranberry, Bearberry, Azalea, Rhododendron and their allies.

The general type is expressed in a gamosepalous calyx with five segments; a gamopetalous corolla, usually bell-shaped, or urn-shaped, with five lobes; ten stamens, inserted either on the axis or on the ovary just free from the base of the corolla, and with the anthers opening by pores and usually provided with two tail-like appendages (*awns*); the ovary composed of five syncarpous carpels, with a single terminal style, and ripening to a valvular capsule or to a fleshy indehiscent fruit.

In some genera the number 4 prevails throughout, in which cases the stamens are 8—e.g. *Erica, Calluna, Menziesia polifolia,* &c.

There are three principal sub-types of this Ericoid flower.

In the Bilberry, Cranberry, Cowberry, and their allies (*Vaccinium*) the ovary is completely inferior, the corolla and stamens being epigynous: in other respects it conforms to the type. The flower is actinomorphic, diplostemonous—or, more strictly ob-diplostemonous, since the outermost series of five stamens are opposite the lobes of the corolla, not alternate with them—and the fruit ripens to a fleshy berry.

In the Strawberry-tree, Bearberry, Azalea, Rhododendron, Heaths, and Ling, and their allies, the ovary is superior, and the corolla and stamens hypogynous, but in other respects conforming to the general type, except as regards the following particulars.

In the Heaths (*Erica*), Ling (*Calluna*), Strawberry-tree (*Arbutus*), Bearberry (*Arctostaphylos*), and in *Loise-*

leuria and *Menziesia*, the corolla is regular and the flower actinomorphic throughout.

But in *Azalea* and *Rhododendron* the corolla is more or less distinctly zygomorphic, and the stamens may be reduced to five.

Thus we see that the floral formula of the Ericoid type may vary in detail as follows:—

$K(5)\ C(5)\ A\ |\ 5+5\ \underline{G(5)}$, e.g. *Arbutus*.

$K(5)\ C(5)\ A\ |\ 5+5\ \overline{G(5)}$, e.g. *Vaccinium*.

$K(4)\ C(4)\ A\ |\ 4+4\ \underline{G(4)}$, e.g. *Erica*.

$K(5)\ C(5)\ A\ |\ 0+5\ \underline{G(5)}$, e.g. *Azalea*.

In spite of these and other small variations in detail, however, it is clear that we have in the Ericoid flower a good type capable of expression in the general formula $K_{(n)}\ C_{(n)}\ A_2 n\ G(n)$, where n represents 4 or 5, and where G may be superior or inferior; while C may be zygomorphic and one whorl of the double series of stamens may be suppressed. Such details as the absence of awns from the anthers, the capsular or fleshy fruit, &c., may be regarded as details to be referred to in the special part of this volume.

As a final floral type, also presenting a number of interesting variations in detail, I select that of the Caprifoliaceæ, the family which includes the Honeysuckles, Elder, Wayfaring Tree, Guelder Rose, and Snowberry.

The general structure of the flower is very similar throughout. It has a completely inferior rounded ovary bearing five epigynous sepals, a five-lobed or five-partite gamopetalous corolla, also epigynous, on the tube of which are inserted five stamens alternating with the lobes —i.e. the androecium is epipetalous and isostemonous.

As a rule the ovary is 3-chambered and bears a single style; but there is some variability in the number of carpels—viz. 4 in *Symphoricarpos*—and a tendency to reduction by abortion of two carpels as the fruit ripens in *Viburnum*.

Moreover, while the corolla is actinomorphic and regular in *Sambucus*, *Viburnum*, and *Symphoricarpos*, it becomes 2-lipped and zygomorphic in the median plane in *Lonicera*.

Consequently we have, with a general conformity to the epigynous, pentamerous, gamopetalous, isostemonous, and syncarpous type of the Caprifoliaceous flower, reductions to three (or four) or fewer carpels, and zygomorphy of the corolla, and the following varieties of floral formula.

$K_{(5)}$ $\underbrace{C_{(5)}\ A_5}$ $G\overline{(3)}$, e.g. Elder.

$K_{(5)}$ $\underbrace{C_{(5)}\ A_5}$ $G\overline{(4)}$, e.g. Snowberry.

$K_{(5)}$ ∤ $\underbrace{C_{(5)}\ A_5}$ $G\overline{(3)}$, e.g. Honeysuckle.

Departures from the type in other small details will be found in Part II.

CHAPTER XVI.

THE PHYSIOLOGY OF THE FLOWER.

Primary functions — To produce pollen and embryo-sac, &c.— and to ensure fertilisation and the nursing of the embryo— Prevention of self-pollination—Adaptations for cross-pollination —Dicœcism and Moncœcism—Polygamy—Hydrophily—Anemophily—Entomophily—Hermaphrodite or Monoclinous Flowers —Proterogyny and Protandry—Dichogamy and Autogamy— Abortion of Stamens—Barren pollen—Pseudo-hermaphrodite flowers—Gynodiœcism, &c.

THE functions of a flower are, primarily, to produce the pollen-sacs and pollen, and the ovules and embryo-sac with their contents; and to ensure that the pollen-grains reach the stigmas or ovules, and that the latter are nursed until they develope into ripe seeds in the fruit.

The primary function of course depends on the fact that the flower consists essentially of sporophylls—stamens and carpels—in which sporangia and spores are developed; but, since it is necessary for the pollen-grains (*microspores*) to germinate on the stigma or on the micropyle, in order that the pollen-tube may reach the embryo-sac (*macrospore*), it is obvious that in the frequent cases where stamens and pistil are on separate plants or flowers, some contrivance for conveying the pollen must exist, e.g. in Pines, Willows, Birches, Oaks, Beech, Chestnut, Hazel, &c.

But even in cases where the stamens and pistil are in the same flower, close examination shows that it is the exception, and not the rule, that the pollen is sown on the stigma of that flower. Numerous adaptations exist to either prevent this "self-pollination" entirely, or to at least delay it, and so admit of pollen from another flower reaching the stigma before that of the same flower can do so.

It is obvious that some general purpose may lie at the bottom of this phenomenon, and we owe especially to Darwin the establishment of the proof that plants derive positive advantages from cross-pollination: that they set more seeds, and produce more numerous and vigorous seedlings as the result of crossing than when continually self-pollinated. This truth lies at the foundation of the multifarious and often very complex mechanisms by which (1) flowers are prevented from self-pollination, and (2) pollen is carried from one flower to another. Self-pollination is of course impossible in unisexual (*diclinous*) flowers, but several degrees may exist in reference to the distance apart of the staminate and pistillate flowers.

Where the male flowers are on one plant and the female on another, as in the Willow, Hop, Briony, *Mercurialis*, we have the extreme case, termed *Diœcism*.

In the Pines, Oak, Beech, Nettle, Euphorbia, *Carex*, *Arum*, the male and female flowers are on the same plant (*monœcious*), either on different twigs or in the same inflorescence, and showing all degrees of relative distance in space and in time of maturing. In some Elms and Nettles and in Pellitory a number of *hermaphrodite* flowers occur amongst the unisexual ones, and they are termed *polygamous*.

On investigating the means by which the pollen is

transferred from the male flowers to the stigmas of the more or less distant female flowers, several agencies are found effective, viz. wind, water, insects and other animals; but especially wind and insects.

Water-pollination (Hydrophily) is rare, but occurs in *Vallisneria*, and some other Hydrocharideæ, where the male flowers are detached and float like boats, and are carried by currents of water, often aided by wind, to the proximity of the female flowers, which project just above the surface of the water and protrude their feathery stigmas so that the pollen-laden anthers of the floating male flowers rub the sticky pollen up against them.

In *Halophila* and *Zostera* the pollen consists of delicate long filaments which are carried under the water and catch on to the long slender stigmas.

Wind-pollination (*Anemophily*) is very common, as exhibited by most of our native trees, Pines, Oaks, Beeches, Birches, Poplars, and Walnut, by Grasses, Sedges, Reeds, &c., and several marked characteristics are evident in all of these otherwise very different plants.

In the first place their flowers are small and numerous, inconspicuous, and devoid of striking colours and scents, or of honey. Many of them, especially where the foliage is expansive and would interfere with the dispersal of the pollen by wind, produce their flowers very early in spring and shower the pollen in the high spring winds before the leaf-buds have opened—e.g. the Hazel—while in others (e.g. the Pines, Firs, &c.) the foliage is so thin that it offers little obstacle to free passage of pollen-laden wind.

Next we notice that the stigmas are for the most part feathery and offer relatively large catchment-surfaces, as in Grasses, Hazel, Hemp, &c., and the female flowers are commonly grouped into dense inflorescences.

Then we observe that enormous quantities of pollen

are produced and shed, and that this pollen is remarkably dry, light, smooth, and dusty, while the male flowers are exposed on dangling, tassel-like catkins—e.g. Poplars, Oaks, Beeches, &c.—or the stamens themselves hang out dangling from the spikelets, as in Grasses, with their large versatile anthers swinging in the wind.

It occasionally happens that the fields and lanes near pine-forests are so covered with yellow pollen-dust that the appearance of a rain of sulphur is suggested to the people, and even boats at sea have been found dusted with wind-borne pollen. In the case of the Pines and Firs the specific gravity of the pollen is lessened by the peculiar air-balloons developed on opposite sides of each grain, increasing the surface considerably and of course aiding distribution by the wind.

A further coincidence met with in these anemophilous plants is their gregarious habit, so well seen in Pines, Beeches, Grasses, Sedges, &c., and readily interpreted in the light of the foregoing facts.

All these phenomena, with numerous subordinate ones, such as the large, swaying, feathery plumes of the taller Grasses, the wind-swept habitats of Pines, Firs, Larches and other mountain forest-trees, and so on, are in accordance with the adaptation of the flowers to wind-pollination.

The following afford examples of wind-pollination (*anemophily*):

Poplars	Firs	Elms
Alder	Cedars	Sweet Gale
Hornbeam	Cypress	Sea Buckthorn
Beech	Yew, &c.	Pines
Walnut	Birch	Larch
Mulberry	Hazel	Juniper
Ash	Oaks	Arbor Vitæ
Chestnut.		

By far the larger proportion of the true, gaily coloured flowering plants, however, are pollinated by the agency of insects, and here again we can recognise amidst the endless diversity in details a number of features in common shown by these *entomophilous* plants.

Typically the flowers are large and conspicuously coloured, not numerous and crowded, and emit characteristic odours, and secrete honey, all of which characters combine to render them attractive to insects, the hairy bodies of which become dusted with the pollen-grains—often viscid and provided with special outgrowths to promote adherence—and carry them from flower to flower.

It is a remarkable fact, however, that entomophilous flowers, and particularly those especially adapted for the visits of insects, are usually hermaphrodite or pseudo-hermaphrodite, and not diclinous and on separate plants, though many of them exhibit intermediate conditions which suggest that the sexes are becoming separate.

In the following the flowers are pollinated by insects (*entomophily*):

Willows	*Vaccinium*	*Rubus*
Mistletoe	Rhododendron	Almond
Barberry	*Arbutus*	Cotoneaster
Maples	Ling	Elder
Gorse	Bittersweet	*Lonicera*
Broom	Fig	*Erica*
Laburnum	Clematis	Azalea
Pyrus	Mahonia	Bearberry
Rosa	Lime	Lilac
Hawthorn	Whin	Privet
Ribes	Robinia	Daphne
Viburnum	*Prunus.*	

In hermaphrodite (*monoclinous*) flowers there are

various arrangements which ensure effective crossing. In *Aristolochia, Eremurus, Scrophularia, Plantago, Anthoxanthum, Alopecurus, Nardus*, and a relatively few other plants, the stigmas are mature and receptive before the anthers have matured their pollen, and by the time the pollen is shed are no longer capable of receiving it: consequently, only pollen from another flower can be effective in these *proterogynous* flowers.

But it is far commoner to find the stamens matured first, and that the anthers have dehisced and shed their pollen while the stigmas are still immature and not yet receptive, as occurs in most Papilionaceæ, Umbelliferæ, Campanulaceæ and Compositæ, *Epilobium*, Gentians; and such flowers are termed *protandrous*.

In the typical cases given above the separation of pollen and stigma is practically as complete as if they were in separate flowers, and this state of affairs—known technically as *Dichogamy*—amounts to physiological diclinism, for it is obvious that a proterogynous flower is physiologically a female flower during its first phases of anthesis and male afterwards, and conversely with protandrous flowers. The Dichogamy is therefore complete.

In a vast number of flowers, however, the Dichogamy is incomplete. For instance, in most Crucifers, Poppies, Buttercups, Roses, &c., the stigmas are immature but some anthers are dehiscing when anthesis begins, and the flower is for a while male only; then, before all the stamens have shed their pollen, the stigmas mature and the flower is hermaphrodite and capable of self-pollination (*Autogamy*). Then comes a period during which, all the anthers having shed their pollen, the stigma remains capable of receiving pollen from other flowers, and the flower in question is physiologically female.

It is clear that in these cases the flower is susceptible at least to an occasional cross, but at the same time assured of good chances of self-pollination if no cross occurs.

The student will also understand that every gradation between complete and incomplete Dichogamy and Autogamy occur, and that the only philosophical explanation of the prevalence of the former is that some advantage to the plant is ensured, as follows from Darwin's prolonged investigation of the subject.

Just as incomplete Dichogamy is comprehensible when we understand the significance of Dichogamy generally, so, too, is a second derived condition of affairs where although both androecium and gynœcium exist in the same flower, one or other is so delayed in its development that either no pollen is produced or no ovules are formed, and so the flower though *morphologically* hermaphrodite (*monoclinous*) is *physiologically* unisexual (*diclinous*). All gradations of this pseudo-hermaphroditism occur, by abortion of all the stamens, or of some only, or by the pollen being incapable of germination; by abortion of the whole ovary, or of the ovules, or by the stigma shrivelling up and being non-receptive, and so on.

Excellent examples of the various cases are furnished by the following native plants: (1) *Polygonum Bistorta, Galium Cruciatum, Anthriscus, Caucalis, Sanicula,* &c., where apparently hermaphrodite flowers with abortive pistils (*pseudo-hermaphrodite male*) occur among the complete ones; (2) *Petasites, Tussilago,* &c., where pseudo-hermaphrodite male flowers are mingled with pistillate flowers. (3) In the Sycamore and Norway Maple, Bay Laurel, *Rumex obtusifolius* and other Docks, Pellitory, &c., we find the polygamous flowers comprise mixed hermaphrodite and pseudo-hermaphrodite male (with rudimentary

pistils) and female flowers (with aborted stamens). (4) In Valerian, Field Scabious, the Vine, *Lychnis viscaria*, *Calamintha*, Ground Ivy, Mint, Thyme, Marjoram and other Labiates, some plants bear only pseudo-hermaphrodite female flowers in which the stamens are reduced to functionless rudiments; while (5) *Dryas octopetala*, *Geum montanum*, and some other Rosaceæ, Ranunculaceæ, &c., have only pseudo-hermaphrodite male flowers on some plants; and (6) in *Rhamnus cathartica*, *Lychnis diurna*, &c., we find pseudo-hermaphrodite male flowers on one plant and pseudo-hermaphrodite female ones on another. In *Silene nutans* (7) some plants have pseudo-hermaphrodite male, others pseudo-hermaphrodite female, and yet others hermaphrodite flowers only; while (8) in *Spiræa aruncus* some plants bear only pseudo-hermaphrodite female flowers, others only pseudo hermaphrodite males, others only hermaphrodite flowers, and yet others bear both hermaphrodite and pseudo-hermaphrodite males.

We thus see that the matter may become very complex. In practice it is common to ignore the difference between true diclinism and pseudo-hermaphroditism (physiological diclinism), and the Thyme, Marjoram, &c., quoted in case (4) above would be termed *gyno-diœcious*, while the plants of case (2) above, and very many Compositæ (*Doronicum*, *Aster*, *Inula*), with truly hermaphrodite and truly female flowers on the same plant, are alike termed *gyno-monœcious*. Similarly, *Veratrum album* with hermaphrodite and truly staminate flowers on the same plant is *andro-monœcious*, as are also the flowers of case (1) above; but *Veratrum album* can be *andro-diœcious*, and the same term is applied to flowers like those in case (5) above.

CHAPTER XVII.

INSECT-POLLINATION—FERTILISATION.

The significance of Entomophily—Wanderings of small insects—Flowers with no very special mechanism—Protection of pollen from rain, &c.—More elaborate mechanisms—Fig—Broom—Explosive mechanism—Barberry—Horse-chestnut—Guelder Rose—Honeysuckle—Artificial pollination—Pollen-tube—Penetration of style—Conifers—Results of pollination—Chalazogamy.

In the consideration of insect-pollination (*Entomophily*) we must never lose sight of the two aspects of the phenomenon, namely, the advantage gained by the flower and that gained by the insect. The flower must be looked upon as a trading house which advertises its wares by means of coloured posters—bright-hued petals, sepals, or bracts, &c.—and by means of more or less powerful scents. But if the visits of insects are to be repeated—in other words, if the customer is to be induced to repeat his call—something substantial must appear at back of the attraction, or the bees, &c., who have much work to do to feed their young, are just as unlikely to keep up fruitless visits as would be a thrifty housekeeper to a shop where she was ill-served.

The solid wares exposed so that the insects may take them, under certain conditions, as honest reward for work done, are the honey and the pollen, or in some cases even other things.

The advantage to the flower is, of course, always the conveyance of the pollen to a more or less distant stigma, and in the process of evolution the mutual balance of advantages has worked out much as it would do in an old-established business house: the bee or other insect, attracted by flaming poster, seductive odour, &c., finds honey and pollen accessible, and carries them off.

But mechanisms in the floral trading house exist which we must look upon as adaptations to prevent waste of pollen, &c., on the one hand, and to so scatter the pollen on the insect that even if he does waste some of it, some is carried to the right spot.

In the above examples, the *rôle* of insects in transferring pollen from one flower to another, or from the stamens to the pistil of the same flower in its hermaphrodite condition, is fairly simple. The mere wanderings of small flies, bees, &c., among the numerous anthers of a Buttercup, Poppy, or Rose, or among the florets in close spicate, umbellate, or capitulate inflorescences of *Plantago*, Umbelliferæ, Rubiaceæ, Dipsaceæ, Compositæ, Labiatæ and Polygoneæ, &c., suffice to ensure an occasional transference and cross-pollination.

Many flowers, especially those which stand wide open, merely attract various kinds of small insects, by their colour, scent, honey, or pollen, and the creeping of these over the parts ensures both self- and cross-pollination.

Examples of flowers with no honey, and no very special mechanism are:—

Clematis Elder.

Examples of flowers with no very special mechanism, but powerfully attractive to insects by their honey and sweet odours, or both, are:—

Willows	Spindle Tree	Lime
Rhamnus	*Rhus Typhina*	Blackthorn
Bird Cherry	Plum	Gean
Cherry	Raspberry	Blackberry
Apple	Pear	Rowan
Hawthorn	Cotoneaster	Dogwood
Ivy	Fly Honeysuckle	Snowberry
Erica	*Vaccinium*	Ling
Arctostaphylos	*Loiseleuria*	Rhododendron
Lilac	*Ligustrum.*	

Good examples of flowers especially adapted to protect the pollen and honey from rain and dew are seen in the bell-shaped corollas of

Erica tetralix	*Vaccinium uliginosum*	*Arbutus*
E. ciliaris	*V. Myrtillus*	Ling
E. vagans	*V. Oxycoccus*	Bearberry
E. cinerea	*V. Vitis-idœa*	*Andromeda*
E. carnea	*Menziesia.*	

There are, however, much more elaborate mechanisms to ensure cross-pollination, of which I will select a few from among our ordinary trees and shrubs; but it should be noticed that by far the best and most interesting or complex cases are afforded by plants other than those with which this book is concerned, and the reader may be referred especially to the Violet, *Salvia*, many Compositæ, Orchids, Asclepiads, *Arum*, *Aristolochia*, *Primula*, &c., for particularly important examples, and to Darwin's works on the Forms of Flowers and on the Fertilisation of Orchids for further particulars of this fascinating subject.

The Fig (Fig. 96) affords a curious and instructive example. The following account refers more especially to the Fig in its southern home, e.g. Naples. The small flowers lining the interior of the hollow floral axis or

receptacle (subsequently the edible part) may be of the following kinds; the ♂ flowers, chiefly in the upper parts, the short-styled ♀ flowers and the long-styled ♀ flowers, chiefly in the lower parts of the hollow floral axis. There are, moreover, two kinds of Fig-trees: one bearing the ordinary figs, and another which bears barren or inedible figs, containing only ♂ flowers and more or fewer short-styled ♀ flowers. This barren fig is termed the *Caprificus*.

A certain species of Gall-wasp visits these inedible figs and becomes dusted with pollen from the ♂ flowers in its attempts to pierce the short-styled ♀ flowers, in which it lays its eggs. It then dies. The hatched-out wasp then creeps out of the fig, and becomes dusted with pollen from the ♂ flowers as it does so. Thus laden it flies to one of the ordinary figs to repeat the process. Here, however, the long-styled ♀ flowers escape its ravages, being protected by their long styles, and only the short-styled flowers can be pierced and galled by the wasp. During its evolutions, however, the wasp transfers pollen to some of the long-styled flowers and these eventually set seed and the receptacle ripens to an edible fig. There are other curious details, but the principle is illustrated by the above.

The Broom (*Sarothamnus*) (Fig. 121) affords a very instructive illustration of floral mechanism. The standard is marked by dark lines leading from its lower part, down the claw, and so to the base of the ovary: in the Laburnum these dark lines lead at once to the honey secreted at the base of the standard, but here there is no honey. Nevertheless bees visit the flowers and obtain pollen as their reward.

The long style, enclosed in the stiff tube of ten stamens, projects into the keel, so that the stigma and the anthers of the longer stamens reach the beak-like

"prow," and there pollen is discharged and held; the five shorter anthers do the same slightly further back.

It must be noted that the style and staminal tube form a stiff spring-like structure.

When a bee alights on the flower it straddles on the wings (*alæ*) as on a saddle, and as it probes the floral base its weight depresses the wings and bears down the pollen-laden keel also. This pressure causes the keel to split suddenly above, and the pollen is explosively shot out by the sudden liberation of the trigger-like springy stamens and style.

Meanwhile the long style had pushed its way into the tip of the keel and lay there also like a spring, forcibly held somewhat like a trigger, and at the moment of explosion it rapidly curls upwards and backwards and escapes out of the ruptured keel.

Two principal events result. In the first place, the bee is dusted with pollen on its ventral side by the short stamens, and on its back by the sharp recoil of the longer stamens. In the second place, the recoil of the style causes the stigma to sharply brush the bee's back and take pollen therefrom, and then it coils up among the exploded and pollen-dusted anthers, so that if the one action fails the other is sure to pollinate the stigma.

The startled bee, finding no honey, then flies away with the collected pollen.

Similar mechanisms occur in *Genista*, Gorse, Robinia, &c., though not always so explosive in character. In *Sophora* I have seen the dropped flowers in thousands on the ground, and visited there assiduously by bees.

Another kind of mechanism is seen in the Barberry (Fig. 105). The flowers droop slightly, and the incurved sepals and petals protect the pollen-laden anthers—which dehisce by window-like valves—and the honey-glands at

the base of the petals from rain. Honey collects between the stamens and the ovary, and in striving to get this any insect may touch the base of a stamen: the latter has an irritable zone at the base of its filament, and the slightest touch causes the hitherto horizontal stamen to spring sharply up to the ovary, like a trigger, dusting both the head of the insect and its own stigma. The insect, on dipping its pollen-dusted head into another flower, rubs some grains on to the rim-like stigma.

Examples of flowers with explosive mechanism—i.e. irritable stamens, or bursting carina, &c.—are:

Barberry	Mahonia	Petty Whin
Broom	Gorse	Dwarf Furze
Kalmia.		

In the Horse-chestnut (Fig. 45) the mechanism for ensuring cross-pollination depends on the fact that the stigma is mature and in position to be dusted by pollen carried by humble-bees visiting the flower, when the anthers are as yet immature—i.e. the flower is *proterogynous*; and also on the relative position of the parts.

When a humble-bee alights on a recently opened flower it finds the seven immature stamens depressed and pendant beneath its thorax as it probes the flower. The style, on the contrary, is sweeping stiffly forwards and upwards, so that its stigma, already mature, just touches the hinder part of the insect's abdomen. Hence if any pollen is dusted on the latter, some of it is rubbed on to the stigma as the insect moves during its probing exertions.

Later on the stamens mature, and sweep upwards and forwards so as to bring the pollen-laden anthers exactly where the stigma was in the last stage, and a visiting bee would now have pollen dusted on to its abdomen in

exactly the right position for it to be rubbed off when another flower in the physiologically female condition is visited.

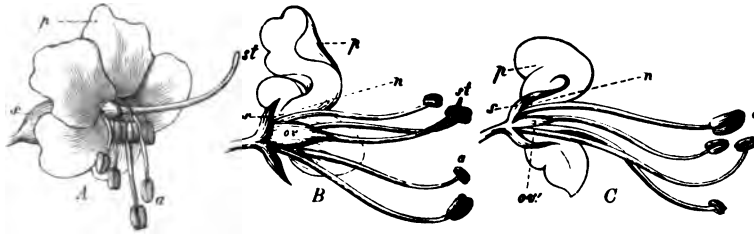


Fig. 45. Horse-chestnut, *Æsculus Hippocastanum*. *A*, a ♂ flower in the physiologically ♀ condition; *B*, the same, cut longitudinally, in the ♂ condition. *C*, a ♂ flower in section (E and P).

The Guelder Rose (Fig. 141) offers a curious case. The outermost flowers of the inflorescence have their corollas much larger than those within the margin; this enlargement is at the expense of the essential organs, for the flowers are quite barren, and serves to advertise the inflorescence as by white flags.

In the Honeysuckle (Fig. 142) the long tube of the corolla is not only an efficient shelter for the abundant honey, but keeps it so far back from the orifice that only long-tongued insects such as moths can reach it conveniently. These are attracted by the increased scent and honey at night. They find the long style projecting straight forwards, about 25 mm. beyond the throat of the corolla; the stamens similarly project about 15 mm. Both the pollen-laden anthers and the stigma are slightly upturned, so that the moth touches first the stigma and then the anthers with its abdomen as it poises to suck.

Examples of long-tubed flowers adapted for Lepidoptera are

Lonicera Caprifolium *L. Periclymenum.*

When the pollen-grain has reached the viscid surface of the stigma it germinates there, and forms the pollen-tube. The latter grows at the expense of the saccharine juices excreted around it, and its apex at once bends down and penetrates the stigma and style, the length of which it traverses until it reaches the ovary; here it passes along the placenta and reaches the micropyle of an ovule, and passes its contents over to the oosphere.

The act of germination is exactly comparable to that of any spore, and is started by the absorption of water and food-materials, and oxygen, at a suitable temperature; this act, and that of artificial germination in sugar-solutions on glass slides, would alone suffice to indicate that the pollen-grain is a true spore.

The turning down and entrance of the tube into the stigmatic tissues is facilitated by the as yet unexplained attraction (chemotropism) exerted by food-materials on the protoplasm, as Pfeffer and Miyoshi have shown for fungus-hyphæ and other cases; and the further growth of the tube in the tissues of the style takes place at the expense of food-materials which it absorbs from the living cells, just as the hypha of a parasitic fungus absorbs them from the living cells of the leaf, stem, or other organ in which it lives.

In many cases (Crocus, Lily, &c.) the tissues of the interior of the style are loose and open, affording a more or less definite passage lined by thin-walled papillate cells, and the tubes grow down in the slimy sugary substances on their surfaces. Such papillose *conducting tissue* is often continued down the walls of the ovary on to the placentæ, and in Orchids (e.g. *Gymnadenia*) it is not difficult to trace the ends of the tubes to the three parietal placentæ: under a lens the tubes look like unspun silk.

In other cases (e.g. Grasses) the tube penetrates the middle lamellæ between the cells of the feathery stigmas, exactly as many fungus-hyphæ do.

In other cases (e.g. Malvaceæ and Caryophyllaceæ) the parasitic action of the pollen-tube is still more marked, for it penetrates the cell-walls and passes across from one cell-cavity to another just as do hyphæ which perforate the cells of their host.

Nor are these the only respects in which pollen-tubes resemble parasitic fungi. Enzymes have been found in them, quite like the enzymes secreted by hyphæ to dissolve their way through the tissues, and food-materials such as starches and sugars are digested by the protoplasms of the tube. It has also long been known that the protoplasm is kept aggregated at the apex of the tube, as in growing hyphæ. In some cases the tube forms curious little cellulose blocks, or stoppers, behind this apical protoplasm (e.g. Orchids) as if to prevent all danger of back-flow.

In Conifers also, where the pollen-tube passes directly into the micropyle and nucellus, and lives for months in the tissues of the latter, one can see the cells in the neighbourhood of the passage bored out by the pollen-tube killed and turned brown as if corroded.

Even apart from these direct proofs of the nutrition and growth of the pollen-tube, we should be able to infer their occurrence from the enormous lengths to which the tubes grow in long-styled plants (e.g. *Crocus*), and the time, weeks and even months, during which they live in the tissues (e.g. Pines, &c.). Moreover, the rapid and far-reaching alterations, induced in numerous cases in organs far removed from the seat of action of the tubes while still in the style, suggest analogies at once with the similar stimulations provoked by parasitic hyphæ in

living tissues. Petals which remain turgid and intact for weeks if the flower is not pollinated may turn limp and brown in a few hours if the pollen-tubes form (Orchids, &c.), and in many cases (Oak, some Orchids, &c.) the ovules do not grow at all until the pollen-tubes begin their descent. All these, and similar phenomena, suggest a stimulated flow of food-materials and water to the centres of activity, and this flow may continue for long afterwards to the excited organs, as evinced in the filling out of the seeds and fruits.

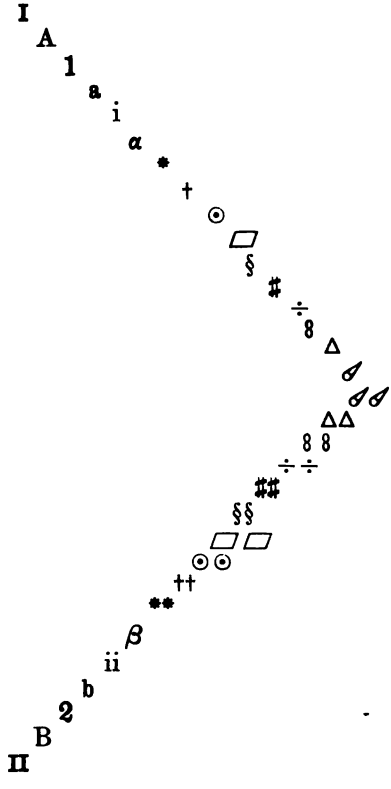
In the vast majority of plants the pollen-tube at length reaches the micropyle of an ovule, a process mechanically facilitated by the bringing of the micropyle close to the base and placenta in anatropous and campylotropous ovules, and probably by chemotropic actions where the tubes have to wander over the surface of others. In Gymnosperms the pollen-grain germinates in the orifice of the micropyle itself.

Recent researches have shown, however, that in Betulaceæ, Hazel, Hornbeam, *Casuarina*, and Walnut, the pollen-tube does not abandon the tissues of the style for the cavity of the ovary, but grows down in the tissues of the carpellary walls and enters the funicle and raphe, passing into the base of the nucellus by the *chalaza*, and thence penetrates the embryo-sac from below, and applies its end to the oosphere. This mode of fertilisation has been termed *chalazogamic* in contradistinction to *porogamic*.

PART II.

SPECIAL.

In order to facilitate the running down of species in the following classification, the signs in the accompanying list are used in sequence and indented as below :—



I. THE FLOWERS ARE UNISEXUAL CONES, MONŒCIOUS OR DIŒCIOUS, THE ♂ CONSISTING OF AN AXIS BEARING A NUMBER OF STAMENS, THE ♀ OF AN AXIS BEARING SCALES WITH OVULES ON THEIR UPPER FACES OR IN THEIR AXILS; BOTH WITH A FEW EMPTY SCALES BELOW. OVULES NOT ENCLOSED IN AN OVARY, WHENCE THERE ARE NO STYLES OR STIGMAS (GYMNOSPERMS). EVERGREENS, WITH NARROW LINEAR, SUBULATE OR SCALE-LIKE LEAVES. ALL ANEMOPHILOUS.

[For (II) see p. 202.]

[The only partial exceptions to the above are, the Yew, which has but one ovule, and the Larch, in which the needles are deciduous. The essential differences between a Cone and a Catkin are as follows. The axis of the male cone bears peltate or scale-like stamens only, and a few empty scales below; that of the female cone, scales with naked ovules, either on their inner faces (placental or ovuliferous scale) or in their axils, with or without subtending scales (carpellary scale) and a few empty scales below. But in neither case does the axis bear bracts with a flower consisting of stamens or carpels with a perianth, or glands, in the axils, as is the case in the catkins of Willows, Birches, &c., &c., nor are the scales on the cone-axis more than double. In *Taxus* the cone is reduced to a single terminal ovule with a few empty scales below. It will thus be seen that the cone is itself a *flower*, with naked stamens or naked ovules; whereas the catkin is an *inflorescence*, bearing flowers of which the ♀ are provided with an ovary enclosing the

seed. The use of the word "Fruit" for the mature cone is conventional only, since there can be no true fruit where there is no true ovary.]

[For (B) see p. 178.]

A. FEMALE FLOWER RESEMBLING A BUD; REDUCED TO A SINGLE, APPARENTLY TERMINAL, NAKED OVULE, SURROUNDED AT ITS BASE BY A RING-LIKE ARIL AND A FEW SPIRAL SCALES; MALE FLOWER WITH ABOUT 6—8 PELTATE STAMENS GROUPED INTO A HEAD, ON A SHORT STALK SURROUNDED BELOW BY THREE OR FOUR SPIRAL SERIES OF SCALES. "FRUIT" A HARD NUT-LIKE OLIVE SEED, INVESTED BY THE CRIMSON FLESHY ARILLUS.

Taxus baccata, L. Yew (Fig. 46). Bushy tree or shrub, dicœcious or, abnormally, moncœcious.

Male flowers surrounded at the base with brownish scarious convex scales, crowded on the lower side of shoots of the previous year; each about 6 (5—8) mm. long, and composed of an axis bearing rounded pentagonal or hexagonal peltate scales, each with about 5—6 (3—8) pollen-sacs, yellow. Pollen devoid of air-sacs, irregularly tetrahedral, rounded, yellowish-white, finely and densely papillate, 25—30 μ in diameter.

Female flowers minute, green, and bud-like, isolated or few together on the lower side of the previous year's shoots; about 5—6 mm. long.

So-called "Berry," sub-sessile, with a few (about 6) basal scales, 8—10 or 12 mm. long; cup-like arillus, fleshy and mucilaginous, scarlet-red or crimson and translucent. Seed ovoid, hard, olive or violet, and protruding. The whole superficially resembling an acorn in its cup.

There is no other plant with a similar naked arillate seed.

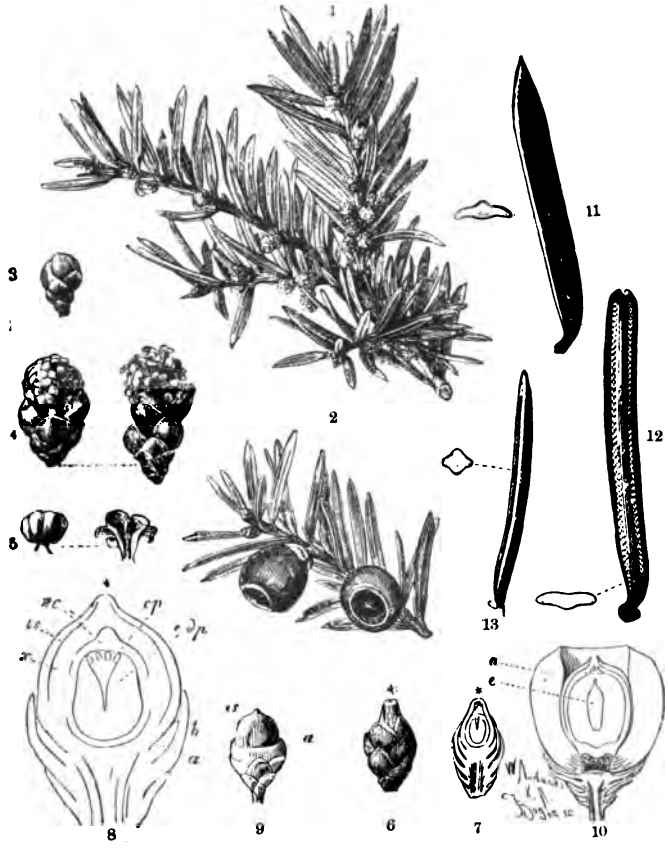


Fig. 46. Yew, *Taxus baccata*, L. 1, branch with male flowers; 2, shoot with two ripe "berries"; 3, young male flower; 4, the same exposing and emptying the anthers; 5, anthers; 6, female flower; 7, the same in section; 8, details of the same: *, micropyle; *ls*, the single integument; *x*, outer part of nucellus which hardens to form the shell; *nc*, nucellus with embryo-sac and endosperm (*edp*); *cp*, archegonia ("corpuscula"); *a*, arillus; *b*, scales. 9, nearly ripe "berry": *a*, arillus; *is*, seed. 10, ripe "berry" in section: *a*, arillus; *e*, embryo. 11, needle and its transverse section; 12, the same of Silver Fir, and 13, of Spruce, p. 177 (Wi).

B. FEMALE FLOWER A CONE OF SEVERAL TO MANY SCALES, BEARING THE NAKED OVULES IN THE INNER AXIL OR ON THE AXILLARY FACE; STAMENS NOT COMPLETELY PELTATE OR IN A STALKED HEAD; "FRUIT" WITH SEVERAL SEEDS, NOT ARILLATE (*Coniferæ*).

[For (2) see p. 180]

(1) Stamens of ♂ cones in whorls of 3, semi-peltate; scales of ♀ cone about 6, in two whorls of 3, the upper bearing an erect ovule in each axil, the lower fleshy and barren; "fruit" a false drupe ("*Galbulus*"), the seeds embedded in the fleshy scales, globoid, blue-black with waxy bloom.

Juniperus communis, L. Juniper (Fig. 47). Dicœcious, rarely moncœcious, bush or low shrubby tree, with reddish bark, slender branches, and subulate pungent leaves in whorls of three.

Male flowers axillary, developed in the previous autumn, enveloped at the base by minute scales, 3—4 mm. long, yellow. Stamens about 15; connective, broad-ovate, pointed and somewhat shield-like. Pollen smooth, spherical; angular when dry.

Female flowers similarly disposed and developed, but bud-like; very small, pale green, with imbricating broad-ovate acuminate scales, surrounding a whorl of three divaricating, whitish erect ovules at the tip.

Cones sub-sessile, ovoid-globose, green, passing to blue-black pruinose fleshy "berries" in the autumn of the second year, about 6—10 mm. long.

No other Conifer has a fleshy drupaceous cone (*Galbulus*) of this nature.

Fig. 47. Juniper, *Juniperus communis*, L. Shoots with ♂ and ♀ flowers. *a* a ♂ flower; *b* and *c* stamen seen from above and from below; *d* pollen; *e* a ♀ flower; *f* the three ovules with the subtending carpellary scales; *g* transverse section of the same; *h* the "berry" (*galbulus*) in section; *i* seed; *k* the same in section (B and S).

(2) Female cones never fleshy in any part, but of woody or sub-woody scales which do not fuse. Monœcious.

[For (b) see p. 181.]

(a) Scales of ♀ cone and stamens of ♂ flower, opposite and decussate; stamens semi-peltate; ovules erect, and borne singly in the axils. Leaves scale-like and opposite. Pollen globoid and devoid of air-sacs. Seeds not conspicuously winged.

Fig. 48. Roman Cypress, *Cupressus sempervirens*, L. ♂ shoot with staminate flowers; *fr* shoot with ♀ cones; *a* stamen seen from behind; *b* the same in longitudinal section; *c* a ♀ flower; *d* one of its scales seen from within, showing the numerous erect ovules; *e* seed (E and P).

(i) Scales of ♀ cone peltate and more or less pentagonal; ripe cone globoid, with several seeds.

Cupressus sempervirens, L. Roman Cypress (Fig. 48). Tree, with dark foliage; the scaly tetrastichous leaves equally distributed and the shoots not flattened.

The ♂ cone oblong, about 4—5 mm. long, yellow, with 10—12 decussate stamens. ♀ cones usually in clusters of two to five, sub-sessile, each of 8—12 woody scales of about 20—30 mm. diameter; scales more or less quadrate or polygonal, smooth or slightly rugose, peltate, with a slight blunt mucro in the centre, greenish-grey to grey-brown and shining outside, dark brown within.

(ii) Scales of ♀ cone not peltate, but oblong and imbricated; ripe cone ovoid elongated, pendulous.

Thuja gigantea, Nutt. Arbor Vitæ. Tall tree with flattened shoots.

The ♂ flowers small; stamens about six, in decussate pairs. The ♀ cones numerous, clustered near the tips of the shoots, ovoid-cylindric and about 12 mm. long; each of 8—12 scales, which are erect and imbricated, elliptic-oblong, decussate, only about 4 of the larger median ones bearing the erect ovules. Leaves small and scaly, crowded, decussate, imbricate. Seeds small with faint notched wing-like margins.

(b) Scales of ♀ cone, and stamens of ♂ cone spirally imbricated, the former closely; ovules in pairs, inverted on an ovuliferous placental scale borne on the inner face of the carpellary scale; seeds winged; pollen with air-balloons; leaves long and narrow, acicular or linear, &c. (*Abietineæ*).

[A partial exception occurs in *Pseudotsuga* which has no air-balloon to the pollen-grain.]

[For (ii) see p. 190.]

(i) Male cones aggregated in proliferous spikes; ♀ cones with small and soon overgrown or fused carpellary scales and large ovuliferous scales, the latter more or less thickened at the free ends to form an apophysis. All cones with about 8—10 barren scales at the base representing an incipient "perianth." Ripe cones fall as a whole; seeds with separable wings which clasp the margins by a rim. Leaves of two kinds; isolated scale-leaves on the long shoots, and acicular, foliage-leaves (needles) in tufts of 2—5 on the dwarf shoots (*Pinus*).

[For (β) see p. 188.]

(*a*) *Female cones ovoid-conical, with a more or less rhomboidal apophysis, which bears a transverse ridge and a central umbo, at the free end of each thickened scale; erect or spreading in flower. Needles in pairs or in threes. ♂ cones yellow.*

[For (**) see p. 188.]

* Needles in pairs on the dwarf shoots, semicircular in section.

† Cones at most about 60—70 mm. long, terminal or nearly so.

⊙ *Leaves (needles) at most about* 50—60 *mm. long.*

▱ *Apophysis grey-brown, with blackish ring round the umbo; cones* 2—3 *(rarely* 4*) in sub-sessile cluster, blunt-ovoid,* 20—50 *mm. long, yellowish or greyish to dark brown, shining, violet when young; ♂ cone yellow,* 10—15 *mm. Leaves average* 35—50 (20—60) *mm., mucronate, twisted, dull green; bushy or prostrate, bark brown.*

Pinus montana, Mill. Mountain Pine. Low straggling, or even prostrate tree, with deep-green foliage.

Male flowers numerous, in dense cones, cylindroid, stalked, up to 15 mm. long, bright yellow or orange. Stamens with large rounded toothed anther-tips.

Female flowers about as large as the male, usually in pseudo-whorls, erect, pruinose violet. Carpellary scales longer than the ovular scales and with prolonged beaks.

Cone sessile or sub-sessile, erect outstanding, or somewhat deflected, mostly in pseudo-whorls or pairs, 2—5·5 cm. long, varying in form and colour, but bright. Umbo pale ash-grey or brown surrounded by a dark ring.

□□ *No black ring round the umbo; cones* 1—2 (*rarely* 3) *together, long-conoid, acute, about* 35—60 (25—70) *mm. long, grey-brown to olive; apophysis sub-rhomboid, flattened or not, upper border ovate, matt, umbo; blunt; red when young. The* ♂ *cone rosy-yellow,* 6—8 *mm. Needles curved or twisted, about* 45—55 (30—80) *mm. long, with callous tip; bluish glaucous to dull dark green. Tall tree with orange or sienna bark.*

Pinus sylvestris, L. Scots Pine (Fig. 49). Erect tree, with sienna or orange-coloured bark, and short glaucous or bluish foliage, but variable.

Male flowers 6—8 mm. long, ovoid, shortly stalked, aggregated at the base of young shoots, leaving the axis bare after falling. Stamens yellow, each with a small roundish anther-comb often reduced to a mere rudiment.

Female flower small, 5—6 mm. long, singly or in pairs, rarely several in a pseudo-whorl at the tip of the young shoot, stalked, deflexed when young, then divaricate, oblong, reddish.

Carpellary scale much shorter than the ovular scale; the latter rounded, broader than long, and with a beak-like process. Ovules very small.

Fig. 49. Scots Pine, *Pinus sylvestris*, L. 1, apex of shoot bearing a female flower; 2, branch with male flowers; 3, cone; 4, the same shedding seeds; 5, female flower; 6, 7, 8, ovular scale with carpellary scale seen from various aspects; 9—12, seeds; 13, male flower; 14, 15, empty stamens; 16, 17, pollen-grain; 18, seedling; 19, pair of needles; 20, the same in transverse section, p. 183 (Wi).

Cone pendent or spreading on a curved stout stalk, 2·5—7 cm. long, ovoid or sub-globose with oblique base, acute or obtuse; varying from yellowish to greenish or brownish-grey and dull.

⊙⊙ *Leaves about* 90—150 (80—160) *mm. long, dark green, stiff and rather blunt. Cones about* 50—75 (45—75) *mm. long, ovoid to ovoid-conic, shining yellowish-brown or with flesh-coloured apophysis. The* ♂ *cone yellow,* 15—25 *mm. long.*

Pinus Laricio, Poir, var. *Austriaca.* Black Pine, Austrian Pine (Fig. 50).

Male flowers 15—25 mm. long, cylindroid, sub-sessile, brilliant yellow. Stamens shortly stalked, with long pollen-sacs, and erect, broad rounded, slightly toothed anther-process. Pollen ellipsoid, smooth, with two ellipsoid air-balloons.

Female flowers sub-terminal, small, single, or in pairs or threes, longish, bright red, sub-sessile; scales shorter than placenta.

Cone 5—8 cm., sessile, erect outstanding or somewhat deflected, long-ovoid or ovoid-globose, bright yellowish to yellow-brown. Apophysis convex, the upper rhomboid irregular, middle and lowermost rounded at upper margin or even pentagonal, shining, with a large pale-brown or greyish umbo.

[The Black or Austrian Pine is distinguished from the Scots Pine by its larger leaves and cones, both ♂ and ♀, the latter red when young, and shining, yellowish-brown, or somewhat flesh-coloured, when mature; and its dark coarse bark. The latter, together with the deeper hue of the foliage, gives the tree a sombre hue, almost black in masses.]

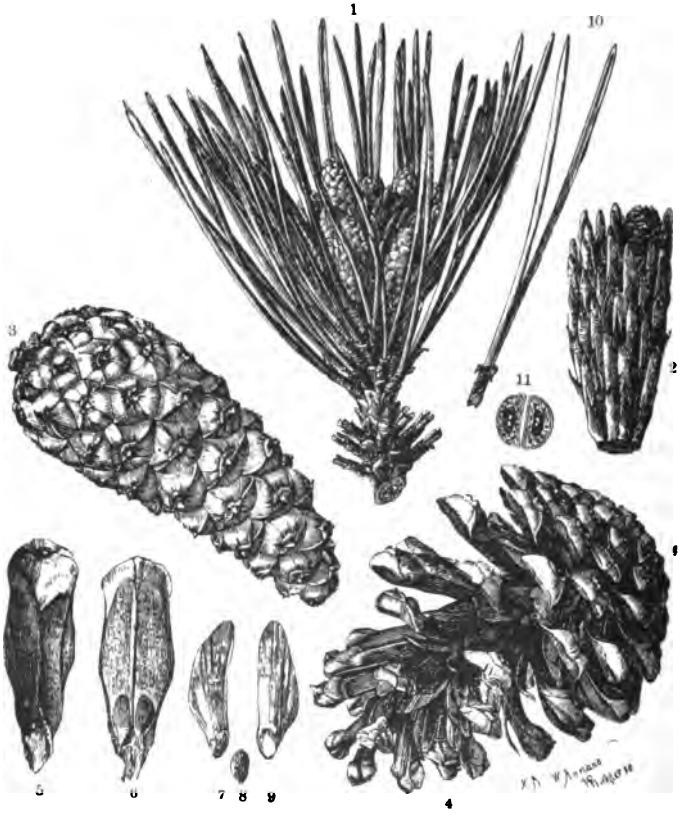


Fig. 50. Austrian Pine, *Pinus Laricio*, Poir. 1, shoot with male flowers; 2, apex of shoot bearing female flower, the dwarf shoots still young; 3, cone; 4, the same shedding seeds; 5—9, ovules and seeds; 10, pair of needles; 11, the same in section, p. 185 (Wi).

†† Cones usually at least 100 mm. long, and needles not less than 120 up to 200 mm.; ♂ cone yellow, 10 mm.

⊙ *Cones* 70—190 *mm. long, grouped laterally, in clusters of* 2—4 *or in whorls of* 5—8;

obliquely broad-ovoid and shining cinnamon-brown, or fawn-yellow; umbo sharp. Male flower 18—20 *mm. long. Leaves about* 140—160 (80—200) *mm., acute, grass green.*

P. Pinaster, Soland. Cluster Pine. It is called the Cluster Pine owing to the whorled clusters of cones. Large tree with coarse bark. Young ♀ cones red-violet.

Male flowers ovoid, 18—20 mm. long, crowded; stamens golden yellow, with large rounded, irregularly toothed anther-processes.

Female flowers small, violet-red, lateral, in pseudo-whorls of 4—8, or more, at the tips of the shoots. Ovuliferous scales slightly longer than the carpellary scales, and often concave outwards like hoods.

Cone nearly sessile, often numerous, directed obliquely outwards in stellate fashion, longish or ovoid, 7—19 cm. long, shining brown, with oblique base and more strongly developed on the exposed side. Apophysis rhomboid, with sharp transverse ridge, and matt-brown umbo, pyramidal on exposed side.

⊙⊙ *Cones sub-terminal, in groups of* 1—2; *resinous, ovoid-globoid,* 100—130 (80—150) *mm. long; shining chestnut-brown, greenish-white when young. Umbo arising from a slight depression.* ♂ *flowers* 8—13 *mm. long. Needles* 120—180 (80—200) *mm., rather twisted, bright green.*

P. Pinea, L. Stone Pine. So apt to form the spreading umbrella head that it is often termed the "Umbrella Pine." Bark reddish-grey.

Male flowers 8—13 mm. long, cylindroid, crowded in spike-like groups, surrounded at the base with brown scales, in the axil of a reflexed brown linear-lanceolate

scale; stamens yellow, with a broad deeply-toothed anther-process.

Female flowers ovoid, greenish, reflexed, singly or more rarely in pairs or in pseudo-whorls of three.

Cone ovoid or sub-globose, very large, 8—15 × 7—10 cm., pale brown and equally developed, often depressed at the base and very resinous. Apophysis rounded at its upper margin, or nearly pentagonal, convex, shining, with 5—6 radiating ridges, of which two are horizontal. Umbo very large, grey-white, blunt.

** Needles in threes on the dwarf shoots, and triangular in section, rather acute and of a pleasant green, 150—200 mm. long; cones in pairs, or whorled, 4—5, long-ovoid, 80—120 mm., shining pale brown with a sharp umbo.

P. Tœda, L. Torch Pine. An American Pine of large dimensions, with reddish-brown broadly-fissured bark and spreading habit. Cones about 12 cm. long, sessile, divaricate, oblong-conic; apophysis swollen, dark brown, with a small reflexed subulate umbo.

[There are some other three-needled Pines in cultivation, some of which have enormous leaves and cones—e.g. *P. Coulteri*—up to 300 mm. long each, but they are not often seen.]

(β) *Scales of cones loosely imbricated and hardly thickened; apophysis half-rhomboidal, oblique, with terminal umbo. Needles in fives.*

* Cones ellipsoid and short, 50—80 mm., crest violet when young, then dull brown; ♂ cones 10—20 mm., brownish red; male

flower 6—8 mm. long. Leaves 55—80 (40—110) mm.; shoots pubescent. Seeds with a very narrow wing.

Pinus Cembra, L. Arolla Pine. Large tree, or bushy, with greyish-brown, fissured and scaly bark, and pubescent shoots.

Male flowers sessile, ellipsoid, about 1 cm. long, with 6—8 membranous basal bracts; ascending, ob-deltoid, with a short obcordate, finely toothed thin membranous; stamens bright yellow; anthers whitish to reddish-violet, especially on the anther-comb.

Female flower long-ovoid, violet; the placental scales ovate and closely imbricated, and for some time distinct from the carpellary scales.

Cone shortly stalked, ascending, ovoid to long-ovoid, obtuse, 5—8 cm.; passing from pruinose bluish-violet to pale brown.

** Cone cylindroid, pendulous, much longer than broad, about 150—200 mm.; scales striate. Needles slender bluish or greyish green, about 100—200 mm.

† Cones about 100—150 mm. long; needles 75—100 (60—110) mm., bluish; ♂ cones yellow with pink-purplish cast, and about 10—12 mm. long.

Pinus Strobus, L. Weymouth Pine. A large Pine of N. America, with smooth greyish to slaty bark, at length rugged. The bluish shorter leaves and the shorter cones distinguish it from the next, with which it is often confounded.

Male flowers in pseudo-whorls of 5—6 on the bases of young shoots; stalked, cylindroid, 7—12 mm. long; stamens yellow with erect, bifid-tipped anther-comb.

Female flowers singly or in pairs, rarely more, somewhat longer than the males; scales horizontal, thick, yellowish-green with red membranous margins.

After fertilisation the ♀ flowers stand oblique and by the winter pass to brown cones, up to 2 cm. long on stalks about 1 cm. long. Mature cone stalked and pendent, 10—15 cm. long; cylindroid-fusiform, acute, somewhat curved, passing from dark violet to brown.

†† Cones about 150—170 (140—220) mm. long, singly or in twos or threes, pale purple when young; needles 125—150 (100—170) mm., greyish-green, very slender; ♂ cones rosy, 16—18 mm. long.

P. excelsa, Wall. Himalayan Pine. The Himalayan Pine, with greyish-brown scaly bark, is difficult to distinguish from *P. Strobus*, except by the longer needles and cones.

Male flowers 16—18 mm. long, narrow-cylindroid, curved and ascending, yellow. Cones stalked, opposite in pairs or pseudo-whorls of 4, rarely single; erect, passing to pendent, conoid-cylindroid, obtuse, curved, and 14—17 × 3·5—7 cm. at maturity and pale brown with resinous drops.

[The difficulty of distinguishing the above species is enhanced because *P. monticola*, of similar habit, has cones (150—200 mm.) and leaves (100—120 mm.) often midway between it and *P. Strobus* in length. The magnificent *P. Lambertiana*, a tree of 300 feet in Oregon, has cones up to 500 mm. and more in length, and is occasionally seen in collections.]

(ii) Male cones isolated; the scales of the ♀ cone not thickened into an apophysis; seed-wings not separable, or if so not

clasping the margins by a rim; needles not in small tufts of 2—5.

(*a*) *Long shoots and dwarf shoots very distinct, the latter with tufts of* 30—70 *needles, the former with isolated scales or needles. Cone scales thin.*

* Needles in tufts of 30—40, deciduous, bright green; ♀ cones purple-crimson when young, then ovoid-ellipsoid, obtuse, 25—35 mm. long; pale brown with few and rather loosely imbricated entire striate scales; scales pointed, hardly exserted. Seeds 5 mm. long with oblique ½ ovate wing 10—12 mm. long. ♂ cones 15—20 mm. long, pale yellow.

Larix europœa, L. Larch (Fig. 51). Tall tree with excessively thin deciduous foliage and slender branches, nodose with the tubercle-like dwarf shoots.

Male flowers about 0·5—1 cm. long, ovoid-globoid to shortly cylindroid according to age, pale green passing to yellow; axis sometimes curved up, base hollow. Stamens almost peltate, carrying the pollen-sacs on the stalk and ending in a compressed triangular, more or less, hood-like green and entire limb. Pollen 75—87 μ, hemispherical, or sub-globoid, pale yellow, rough, with three pores.

Female flower about 1—1·5 cm. long, cylindroid, blunt, the axis curved upwards at its base; with broad, obovate, thin purple-red scales, the emarginate apex with midrib prolonged into a subulate out-curved process, green on the lower scales, red on the upper.

Cone about 1·5—2 cm. long, ovoid, obtuse, ripening to pale brown, on an evident stalk. Ovular scales rounded,

Fig. 51. Larch, *Larix europæa*, D.C. 1, branch bearing a long shoot and several dwarf shoots, and (*a*) a proliferous cone; 2, shoot with male (♂) and female (♀) flowers; 3, male flower; 4 and 5, unopened, and 6, ruptured stamens; 7 and 8, scale of female flower seen from without and within; 9, ovuliferous scale; 10, cone; 11—14, seeds; 15, dwarf shoot in section; 16, leaf and its section, p. 191 (Wi).

ovate, slightly curved, the tips of the barren scales just showing beyond the lower ones.

[This is the only one of our Conifers with deciduous leaves. The Cedars are the only other Conifers with numerous needles in the tufts.]

** Needles evergreen, 30—70 in the tufts, dark green; ♀ cones large, 80—100 mm. long, with very numerous and closely imbricated scales; ellipsoid-oblong, purplish in youth; carpellary scales minute, fused, not exserted. ♂ cones yellow-brown, 30—50 mm., cylindroid. Seed 10—12 mm., with very broad rounded-cuneate wing up to 40 mm. long.

Cedrus Libani, Barr. Cedar of Lebanon. Broadly-spreading tree with very dark foliage in tiers.

Male flowers about 5 cm. long, ovoid, erect, yellowish. Female flower about 5 cm. long, chiefly towards the apex of the tree, purple passing to yellowish, with very short, broad and thin, closely imbricated, obovate and eroded bracts; scales sub-orbicular, irregularly dentate.

Cones ellipsoid-cylindroid, depressed above 6·5—9 (4·5—12) × 4·5—6 (4—7) cm., on short stalks, matt brown, resinous, especially above.

[The two geographical races or sub-species, *C. Atlantica* and *C. Deodara*, differ chiefly in habit; the former are usually smaller and more rigid, with shorter leaves and smaller cones, the latter more lax and pyramidal, with longer and paler leaves.

C. Atlantica, Marr. Atlas Cedar. The cone is smaller, and more cylindroid and flattened at the top, the scales more shining, pale brown.]

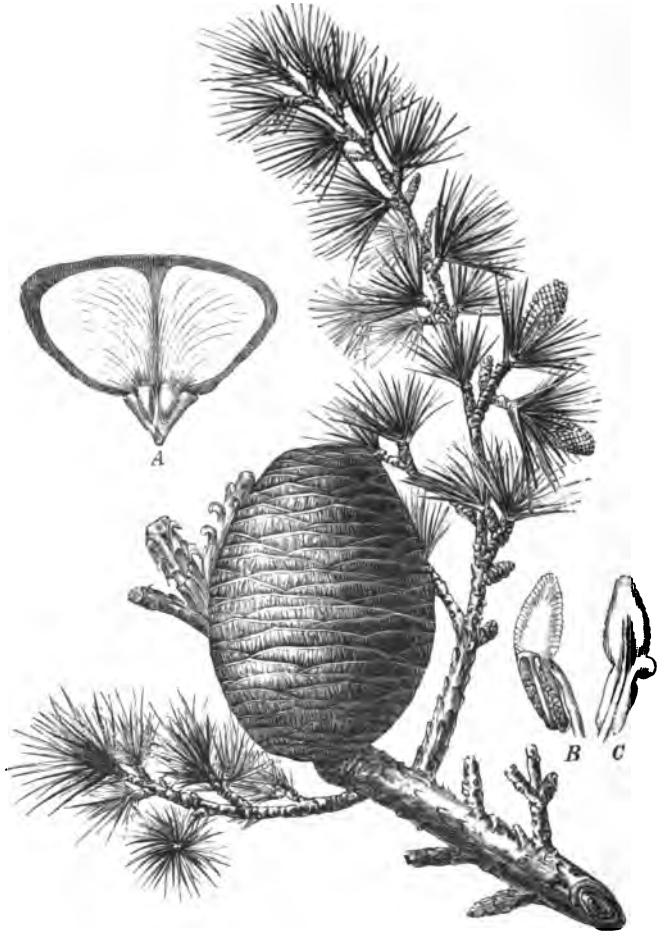


Fig. 52. Deodar, *Cedrus Deodara*, Loud. Shoot with ♂ and ♀ cones. *A*, seed-bearing scale; *B* and *C*, stamens, p. 194 (E and P).

C. Deodara, Loud. Deodar (Fig. 52). Cones ovoid-cylindroid, 8—13 × 5—7 cm., the young ones with a bluish

bloom, passing to pale reddish-brown, shortly stalked, often in pairs.

(β) *Long shoots only distinguishable; leaves isolated, acicular or linear, and always spirally inserted, though often twisted out of position.*

* Needles acicular, 4-angled, crowded and somewhat curved forward, but hardly pseudo-distichous; cone cylindroid, 100—150 mm. long, pendulous and falling as a whole; scales thin, notched and striate, and somewhat loosely imbricated; carpellary scales not exserted. ♂ cones about 20 mm., pinkish-yellow, cylindroid. Seed-wing separable, embracing the seed as in the bowl of a spoon.

Picea excelsa, Lk. Spruce (Fig. 53). A large cylindroid tree, with thin reddish-brown periderm passing to brown scaly bark; foliage dark, the branches sweeping downwards and curved forwards. Leaves on prominent cushion-like bases, about 10 to 25 mm. long, mucronate.

Male flowers on long stalks, isolated in leaf-axils, 20—27 mm. long, with pale green basal bracts; ovoid or subglobose when young, and, owing to the purplish brilliant red imbricated anthers, very conspicuous and resembling strawberries. Stamens red, pollen-sacs yellow. After anthesis golden-yellow from the pollen clinging to the elongated and curved pollen-sacs.

Female flowers sessile at the tips of the preceding year's shoots at the apex of the tree; at first erect and 4—5 cm. long, cylindroid, with thin, emarginate or toothed, carmine to purplish-red ovular scales. Ripe cones pendent

and falling as a whole; cylindroid-fusiform, 10—16 cm.

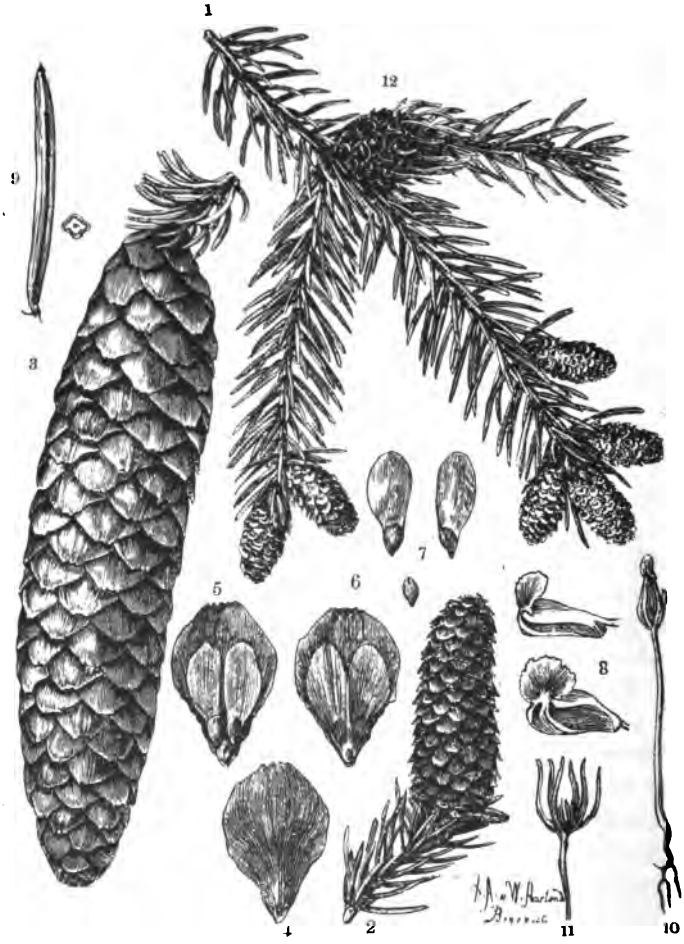


Fig. 53. Spruce, *Picea excelsa*, Lk. 1, shoot with male flowers, and at 12, a *Chermes* gall; 2, female cone terminating a shoot; 3, ripe cone; 4, 5 and 6, cone-scales; 7, seeds; 8, stamens; 9, leaf and its transverse section; 10 and 11, seedling, p. 196 (Wi).

long × 20—25 mm. broad, passing through green to pale brown. Barren scales very short, toothed and ciliate.

[*Picea alba, P. nigra,* with small cones, and a few others are planted.]

** Needles not 4-angled, but flat, linear; carpellary scales with points projecting beyond the ovuliferous scales; seed-wings not separable.

† Cone ellipsoid, tapering at both ends; carpellary scales very evident, 3-pronged, exserted; pollen devoid of air-sacs; leaves linear, obtuse, about 20—30 mm. long, crowded, curved forwards and hardly pseudo-distichous.

Pseudotsuga Douglasii, Carr. Douglas Fir (Fig. 54). Large pyramidal tree with dense light green foliage. Cones about 50—90 mm., falling as a whole; scales entire, barren scales lyrate with a long median and two short lateral points. Bark thick, reddish-brown, with deep irregular fissures.

Male flowers long-ovoid, about half as long as the needles, crowded singly in the leaf-axils.

Female flower small, isolated or grouped at the tips of short shoots.

Mature cones pendent, 5—9 × 3—3·5 cm. Scales broad, linear and leaf-like, toothed towards the bifid apex, the midrib prolonged into a long subulate process, giving the whole a trident-like appearance as it projects beyond the rhomboid pale brown ovuliferous scale.

†† Cone cylindroid-oblong, rounded at each end, and erect; with numerous entire scales, from between which the points of the barren scales protrude and are reflexed;

at maturity the scales fall, leaving the bare axis; pollen with air-sacs; leaves linear, notched at apex, strongly pseudo-distichous.

Fig. 54. *Pseudotsuga Douglasii*, showing the pendent cone, and exserted three-pronged carpellary scales, p. 197 (V).

Abies pectinata, D.C. Silver Fir (Figs. 55 and 56). Tall tree, differing from the Spruce in its flattened and apparently distichous leaves; the erect cones with deciduous and exserted carpellary scales; and the more horizontal branches with spray displayed in one plane, and in having an inseparable seed-wing. Cones about 80—170 mm., pale green when young; carpellary scales irregularly dentate and with a single point: ♂ cones yellowish-green to red, about 20 mm. long.

Male flowers crowded in the leaf-axils of shoots of the preceding year, especially towards the tip of the tree; elongated, 20—27 mm. long, with numerous imbricated, pale green, basal bracts, the upper of which are laciniate. Stamens greenish-yellow, with short pollen-sacs.

Female flowers borne on the upper side of the apex of last year's shoots of the topmost branches in August; erect, cylindroid, about 27—30 mm. long, with numerous pale green fimbriated basal scales. Scales pale green, obovate, toothed, the tip of which is prolonged and spreading beyond the much shorter rounded-ovate ovular scales. Mature cone cylindroid, erect, 8—16 cm. long, somewhat tapering at either end, the scales falling, and leaving the bare axis (Fig. 56).

[A number of other Silver Firs are in cultivation, of which *Abies bracteata* with enormously long pointed barren scales; *Abies concolor* with barren scales not exserted; *Abies Pinsapo* with thick and almost fleshy leaves; *Abies nobilis*, *Abies Nordmanniania*, &c., may be mentioned. They are striking objects when the glaucous silvery foliage, to which they owe their popular name, is at its best.]

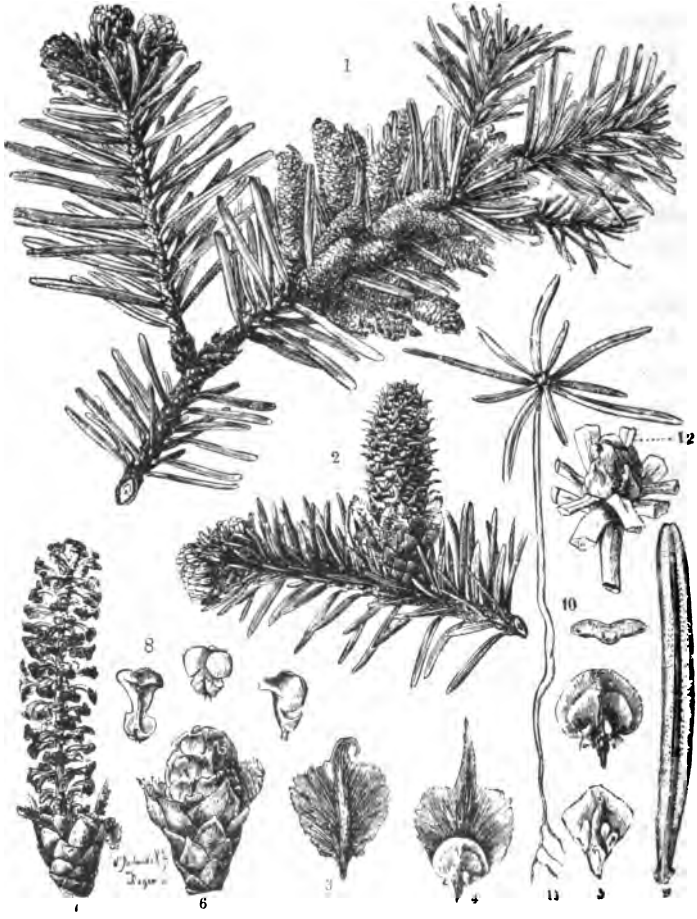


Fig. 55. Silver Fir, *Abies pectinata*, D.C. 1, shoot with male flowers; 2, shoot bearing a female flower; 3 and 4, scales of female flower from within showing ovuliferous scale on the inner face; 5, ovuliferous scales; 6 and 7, young and old male flower; 8, stamen in various positions; 9, leaf, and 10, its transverse section; 11, seedling; 12, plumule, p. 199 (Wi).

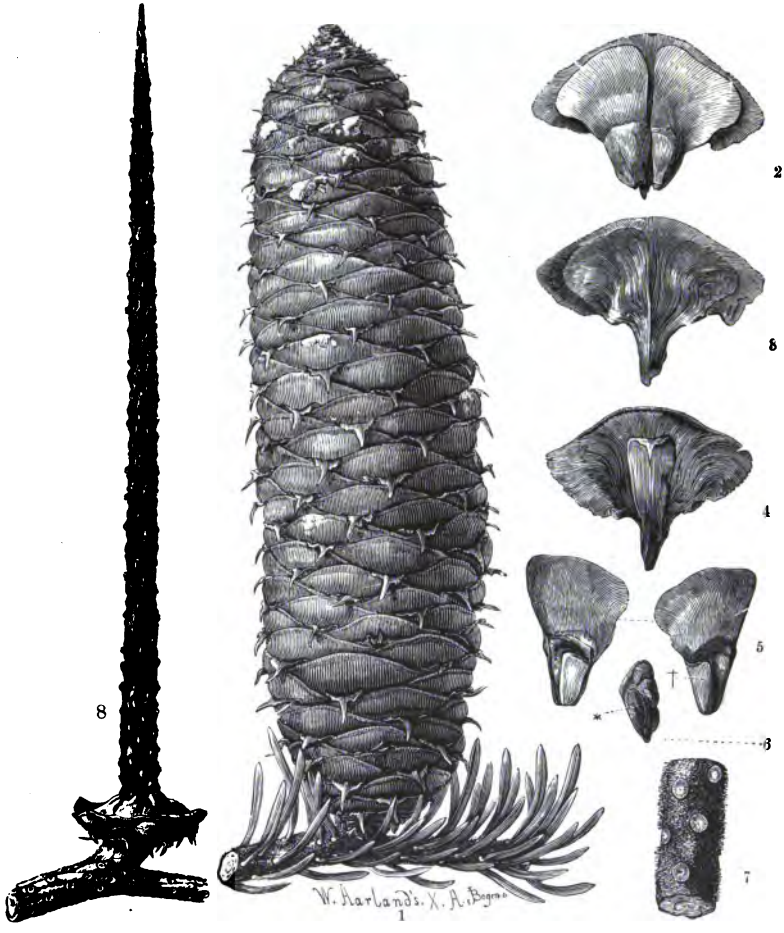


Fig. 56. Silver Fir. 1, ripe cone; 2, placental scale and seeds from within; 3, the same with seeds fallen; 4, scale from without, showing the smaller carpellary scale; 5, seeds with wing, the † points to the inturned part holding the seed; 6, seed with wing removed, the * points to a resin gland; 7, piece of shoot with leaf-scars; 8, axis of ripe cone from which the seeds and scales have fallen, p. 199 (Wi).

II. THE FLOWERS ARE NOT TRUE CONES, AND THE OVULES ARE ALWAYS ENCLOSED IN AN OVARY, OF ONE OR MORE CLOSED CARPELS AND WITH ONE OR MORE STIGMAS AND USUALLY A STYLE AS WELL (ANGIOSPERMS). THEY MAY BE UNISEXUAL OR HERMAPHRODITE, AND MONŒCIOUS OR DIŒCIOUS, BUT THE FLOWERS ALWAYS STAND IN THE AXIL OF, OR ARE INSERTED ON A SCALE OF THE INFLORESCENCE, OR EACH HAS A PERIANTH OF ITS OWN. THE FOLIAGE NEVER CONSISTS OF TRULY ACICULAR OR SCALY EVERGREEN LEAVES, THOUGH THEY MAY BE VERY SMALL AND EVEN SCALE-LIKE IN FORM—e.g. Ericaceæ, Tamarisk, "Ruscus."

[However cone-like the inflorescence may appear to be—e.g. the ♀ catkin of *Alnus*—the stamens or carpels never constitute the scales themselves: there are always at least scales in addition to either ♂ or ♀ flowers on the flowering axis.]

[For (B) see p. 274.]

A. FLOWERS UNISEXUAL (*DICLINOUS*), CONTAINING STAMENS ONLY, OR PISTILS ONLY, BUT NOT BOTH, EXCEPT OCCASIONALLY AS RUDIMENTS.

[For (2) see p. 264.]

(1) Inflorescence a catkin, or catkin-like spike, composed of scales subtending or bearing flowers or compressed groups of flowers; flowers never enclosed in distinct calyx and corolla, though there may be a green or brown membranous perianth or not.

[For distinctions between a Catkin and a Cone see Note p. 175.]

[For (b) see p. 232.]

(a) Staminate (♂) and pistillate (♀) flowers on different inflorescences and plants (*diœcious*).

(i) Flowers devoid of any perianth (*achlamydeous*); singly in the axils of simple covering scales, and at most accompanied by one or two glandular scales or a cup-like disc at the base. The catkins or catkin-like spikes are therefore simple—i.e. each cover-scale or bract is single, and not compounded of several fused scales. [For (ii) see p. 229.]

(*a*) *Catkins with entire scales, more or less stiff and erect; each flower with one or two scale-like or peg-like glands at its base. Leaves narrow or lanceolate to ovate, elliptical, &c., but never broadly cordate, angular, or lobed.* [For (β) see p. 223.]

* Catkins sessile, arranged in terminal erect spikes; each ♀ flower with two lateral basal fleshy scales (*bracteoles*). Each scale of the ♂ catkin with 4 free stamens with red anthers; each scale of the ♀ catkin with an ovary bearing two filamentous red styles, ripening to an indehiscent nutlet with 1 seed, not comose. Fruit flanked by the adherent wing-like fleshy bracteoles. Plant aromatic with resinous glands.

Myrica Gale, L. Bog Myrtle, Sweet Gale (Fig. 57). A bog bush with rather willow-like aspect, and waxy-resinous, fragrant secretions. Leaves deciduous, membranous, exstipulate, entire except at the slightly toothed apex; matt green above, paler beneath, and with scattered golden glands.

Catkins stiff and erect, ovoid, the ♂ about 1·5 (1—3) × 0·8 cm., and brownish, the ♀ about half as long and

greener. Flowers dicœcious, but hermaphrodite flowers may occur: anemophilous. Male flowers with 4 free stamens, and red anthers, but no bracteoles. Pollen powdery.

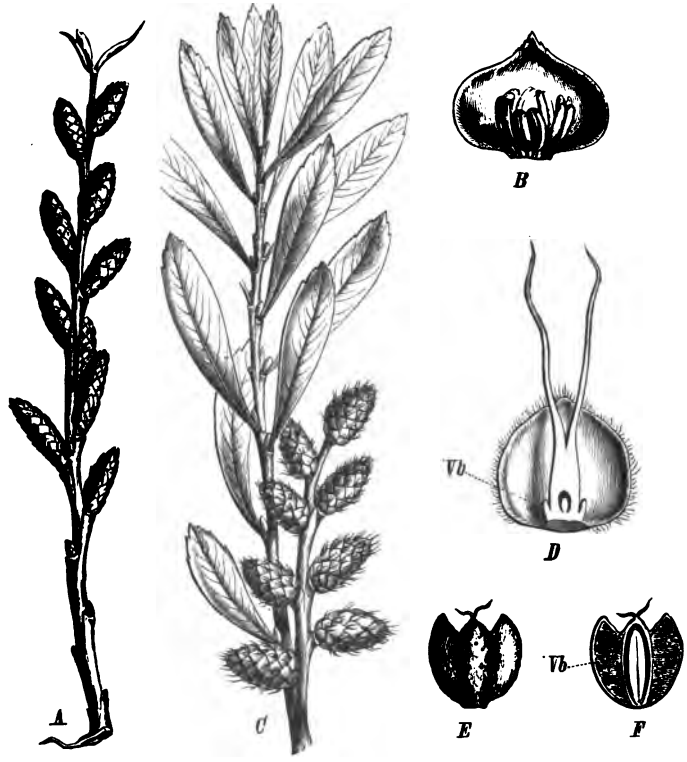


Fig. 57. Sweet Gale, *Myrica Gale*, L. *A*, shoot with ♂, and *C*, with ♀ catkins; *B*, scale with ♂ flower; *D*, scale with ♀ flower, the latter in section; *E*, fruit with its two fused lateral bracteoles; *F*, the same in section, p. 203 (E and P).

Female flowers with a small, long, ovoid ovary, subtended by the two lateral bracteoles, which grow and

adhere to the sides forming wing-like appendages to the fruit (Fig. 57, *E*). Styles 2, divaricating, red. Ovule 1, basal, orthotropous. Fruit dry, drupaceous, and winged; densely sprinkled with golden glands.

** Catkins more or less erect, but not collected into a terminal, erect, stiff spike; each terminating a dwarf shoot, each flower with 1 or 2 minute peg-like or scale-like honey-glands placed antero-posteriorly. Catkin scales entire and of one colour (*concolor*), or tipped with brown or black (*discolor*). Stamens 1—5 (rarely more, and not normally 4). Ovary more or less flask-shaped, with bifid or broad stigmas: entomophilous and anemophilous. Ovules numerous, minute, on parietal placentas. Fruit a dehiscent capsule with numerous minute comose seeds (*Salix*).

† Catkins flowering late, with the foliage or after; distinctly, though sometimes shortly, stalked and with leaves at the base, lateral on the twigs or apparently sub-terminal. [For (††) see p. 215.]

⊙ *Catkins small, usually only about* 5—15 × 5—8 *mm., and arising from buds near the apex of long shoots, therefore pseudo-terminal. Plants dwarf, prostrate, or creeping; mostly rare alpine or northern forms. Catkin-scales persistent. Stamens* 2, *free.* [For (⊙⊙) see p. 208.]

▱ *Scales of the catkin concolor, i.e. all one colour, green or pale. Style short; nectary* 1 *in the* ♀ *flower,* 2 *in the* ♂ *flower, papyraceous, unceolate or disc-like.*

§ *Nectary papyraceous; scales of the catkin nearly glabrous, ciliate; ovary sub-sessile, glabrous.*

Salix herbacea, L. Dwarf Willow. The smallest woody plant of the British Flora: prostrate and creeping. Leaves oval or sub-orbicular, glabrous, shining on both sides, reticulate.

Catkins very small and few (2—12), flowered, ovoid or sub-globose, sub-terminal, on short pubescent stalks with about two basal leaves; the ♂ about 4—8 × 4—6 mm., the ♀ about 10 × 5 mm. Glands two. Scales ciliate or glabrescent. Yellowish-green, discolor or nearly concolor. Stamens 2, free, glabrous. Ovary ovoid-conic, sub-sessile; style short, stigma bifid. Capsule relatively large, glabrous.

§§ *Nectary disc-like and slit, urceolate. Scales velvety, rosy-purplish or brown, ciliate; ovary sessile, tomentose.*

Salix reticulata, L. Reticulate Willow. Catkins flowering late, terminal on long naked stalks, ending the sparsely foliaged shoots.

Each catkin slender cylindric, loose-flowered, the ♂ about 1—2 × 0·5 cm., the ♀ about 0·8—2 × 0·5 cm. Glands forming a slit disc, or bifid. Scales rounded and rosy to purplish, passing to rusty-brown, smooth dorsally, villous inside and ciliate. Rachis and purple stalk with scattered long hairs. Stamens 2, free, glabrous, with reddish-violet anthers. Ovary sessile, ovoid, obtuse, white-tomentose; style short, often split; stigmas short, thick, purple-red and often bifid. Capsule pubescent, purple.

□□ *Scales discolor, green or pale at the base, and purple, brown to black at the tips; velvety, silky or tomentose. Ovary more or less hairy; style at least half its length. One nectary only in both ♂ and ♀ flower.*

§ *Ovary pedicellate.*

‡ *Ovary glabrescent, pedicel short; style long.*

Salix Myrsinites, L. Whortle Willow. An alpine scrubby willow, only on Scotch and Irish mountains.

Catkins with the foliage, apparently terminal on a leafy stalk, about 1·2—2 × 0·8—1 cm., densely covered with white hairs. Scales long or spathulate, black-purple, with dense white hairs. Stamens 2, free, glabrous, yellow with globoid purple anthers. Ovary shortly pedicellate, elongated, reddish or claret-coloured, white pubescent or tomentose; style split, purple-red, and stigmas divided.

‡‡ *Ovary hairy; pedicel long, style short.*

Salix repens, L. Creeping Willow. Small, usually prostrate, and very variable in foliage and colouring.

Catkins with or just before the foliage, lateral, sessile or nearly so with bracts, but not leaves, as the basal scales, ovate or oblong; the ♂ about 6—16 × 6—12 mm., the ♀ about 5—12 × 5—8 mm., becoming loose and sub-globose in fruit. Gland 1 only. Scales ligulate or obovate, varying in colour from yellow or red at the base and black at the tips, to purplish or brown, covered with dense long or velvety hairs.

Stamens 2, free, with long glabrous filament, and ovoid anther yellow passing to blackish. Ovary pedicellate, conoid, silky pubescent to grey-tomentose or glabrous; style usually very short; stigmas yellow, rosy or purple, entire or split and diverging or not. Capsule pubescent or tomentose, rarely glabrous, on a stalk at most three and a half times as long as the gland.

§§ *Ovary sessile or sub-sessile.*

‡ *Catkins sweet-scented on flowering. Anthers violet. Nectary-gland of the ♀ flower long and thin, and may reach half-way up the sessile ovary.*

Salix Lapponum, L. Downy Willow. Catkins lateral, thick, dense-flowered, sessile or sub-sessile, white-tomentose, appearing before or with the foliage; about 2—3 × 1 cm., the ♀ on an evident stalk, with a few basal leaves. Gland 1, linear-oblong, half as long as capsule. Scales spathulate, distal moiety black, long, hairy on the back. Stamens 2, free, glabrous; anthers yellow, passing to violet and brown. Ovary sessile, white-woolly; style long; stigma divided.

[Closely allied to this is the very rare northern species *S. lanata*, L., the Woolly Willow, a dwarf and prostrate Arctic species, with silky-woolly twigs and leaves.

Catkins sessile or sub-sessile, two or three together at the ends of the shoots, about 5 × 1·5 cm., densely silky and with a golden shimmer. One gland only. Scales oblong-lanceolate covered with long silky hairs, persistent; base pale, apex dark. Stamens 2, free, glabrous. Ovary sessile, glabrous; style fairly long, divided; stigmas bifid.]

♯♯ *Catkins not especially fragrant. Anthers orange. Nectary of ♀ flower slightly longer than the short pedicel.*

Salix Arbuscula, L. Bushy Willow. Small alpine form with tufted twigs.

Catkins small, appearing just after the foliage, with minute basal leaves on the peduncle; about 1·5—3 × 0·5—1 cm. Scales rounded spathulate, short, yellowish to rusty, velvety, ciliate. Stamens 2, free, glabrous, with orange anthers. Ovary ovoid-conic, somewhat tomentose, on a pedicel shorter than the gland. Style long; stigmas often breaking into filiform arms.

⊙⊙ *Catkins large, usually at least* 25—40 × 10—15 (20—80 × 6—25) *mm.; arising from buds down the sides of last year's twigs, therefore lateral. Shrubs or trees of erect habit.*

□ *Scales concolor, caducous; style short; ovary glabrous.* [For (□□) see p. 213.]

§ *Scales glabrous or nearly so. Glands 2, or in the ♀ flower one only. Ovary sessile. Weeping in habit.*

Salix Babylonica, L. Weeping Willow. Tree, well-known from the pendulous branches and weeping habit.

Catkins appearing with the foliage or just after, on leafy peduncles, the ♂ 2—4 × 0·6—0·8 cm., rarely seen, but catkins with mixed ♂ and ♀ flowers occur; the ♀ compact and usually curved, and thinner. Scales glabrous or glabrescent. Gland broad and rounded. Capsule small, sessile, glabrous, oblong-conic, pale green. Style short: stigmas emarginate.

§§ *Scales pubescent, ciliate, or silky haired. Habit not weeping.*

♯ *Stamens 2, free.*

÷ *Both ♂ and ♀ flowers have 2 glands. Ovary pedicellate; leaves glabrous. Petiole sometimes glandular.*

Salix fragilis, L. Crack Willow (Fig. 58). Tree, often well characterised by the easy snapping of the twigs at the articulation with the branches.

Catkins shortly stalked, on leafy laterals of the preceding year, numerous, cylindroid, with crowded flowers; the ♂ usually large, about 2—4·5 × 0·7—1·2 cm., the ♀ about 2—6 × 0·6—1 cm. Each flower with 2 glands, anterior and posterior. Scales rather long, uniformly yellowish-green, hairy on the upper side and especially silky in the ♂. Stamens 2, free, hairy at the base; anthers bright yellow passing to brown. Ovary on a pedicel longer than the gland, conoid-pointed, glabrous; style short, with

shortly diverging bifid stigmas. Capsule hairy; the scales of the fruiting catkins caducous.

[The peculiarity of snapping at the articulations is only shared by the twigs of *S. triandra* and certain hybrid or varietal forms. The stamens of *S. fragilis* are not

Fig. 58. Crack Willow, *Salix fragilis*. 1, male, and 2, female flowering shoot; 3, male, and 4, female flower, enlarged; 5, vertical section of latter; 6, ripe capsule; 7, seed, p. 209 (Wo).

always 2, however, but occasionally 3—5. Catkins containing both ♂ and ♀ flowers occur abnormally.]

÷÷ *The ♂ flower has two glands, the ♀ only one. Ovary sessile. Leaves silky; petiole glandular.*

Salix alba, L. White Willow (Fig. 60). A large tree, like *S. fragilis*, and not always easy to distinguish from it; but the twigs and lanceolate leaves are silky, and the former not brittle at the joints.

Catkins numerous, sub-sessile, on short, leafy laterals of the preceding year's shoots, cylindroid, slender and often curved; the ♂ 4—5 × 0·8—1·2 cm., the ♀ 5—6 × 0·6—0·8 cm. or thereabouts. Scales greenish-yellow, white silky above, as is also the rachis; those of ♀ caducous. Glands two, anterior and posterior. Stamens 2, free, hairy; anthers yellow. Two glands at the base of the flower. Ovary sessile, conoid, smooth, with a short style and short bifid stigmas. There may be one gland only at base of the ovary. Capsule ovoid-conic, sessile or sub-sessile on a pedicel shorter than the gland.

[*Salix vitellina*, an Osier form with golden-yellow twigs, is a well-marked variety. *S. Russelliana*, Sm., the Huntingdon Willow, is probably a hybrid between *S. alba* and *S. fragilis*; and *S. Babylonica*, L., the Weeping Willow, from Asia, is allied (see p. 209); its catkins occasionally bear both ♂ and ♀ flowers.]

♯♯ *Stamens 5, or sometimes more. Ovary shortly pedicellate. Each flower with two glands. Leaves laurel-like and with petiolar glands.*

Salix pentandra, L. Bay Willow (Fig. 59). A shrub or small tree, with broad leaves.

Catkins appearing with the foliage, cylindroid, dense; the ♂ 2·5—5 × 1—1·5 cm., ♀ 2—6·5 × 0·7—1·2 cm. Glands 2 in each flower; but in the ♂ there may occasionally be 4 or even 6. Axis pubescent. Scales ligulate to ovate, yellowish-green and ciliate-pubescent, caducous. Stamens

Fig. 59. Bay Willow, *Salix pentandra*, p. 211 (Sc).

normally 5, but may be 4—10 or rarely 12; hairy below, anthers large, yellow, passing to brown. Ovary shortly

Fig. 60. White Willow, *Salix alba*. 1, male catkin; 2, a male flower; 3, shoot with female catkin; 4, female flower; 5, fruiting catkin; 6, fruit with escaping seeds; 7, seed with its coma. 2, 4, 6 and 7, magnified, p. 211 (Sw).

pedicellate, cylindroid-conic, glabrous, style short, divided; stigmas bifid, yellow. Capsule large (6—7 mm.), ovoid-conic.

▱▱ *Scales discolor and persistent: ciliate, hairy.*

§ *Stamens* 3. *Only* 1 *gland in the* ♀, 2 *in the* ♂ *flower. Leaf ovate or rather broad; petioles glandular. Ovary glabrous.*

Salix triandra, L. Almond Willow (Fig. 61). Shrub or small tree.

Catkins on leafy, lateral, short shoots, on twigs of the preceding year; lax-flowered, with white-pubescent axis, the ♂ about 2·5—8·5 × 1 cm., the ♀ about 3—7 × 0·5—0·6 cm. Glands 2 in the ♂, but only 1 in the ♀ flower. Scales

Fig. 61. Almond Willow, *Salix triandra*, p. 213 (Sc).

greenish-yellow, glabrous at the back, ciliate, somewhat caducous. Stamens 3, long, smooth, with golden anthers. Ovary pedicellate, oblong-conoid, smooth; style obsolete;

stigmas thick and divaricating. Capsule ovoid-conic with reflexed valves.

[Cultivated for osier work; leaves whitish beneath, but not silky as in *S. alba*. The only one of our willows with 3 stamens normal; but *S. fragilis* occasionally resembles it in this respect.]

§§ *Stamens 2, free; ovary velvety. Dwarf creepers with more or less ovate or oblong-lanceolate leaves, silky beneath.*

‡ *Ovary sessile or sub-sessile; style long. Catkins fragrant. Leaves 3·5—9 × 0·8—3·5 cm., the tomentum beneath hiding the venation.*

Salix Lapponum, L. (See p. 208.)

‡‡ *Ovary pedicellate. Leaves varying from linear-oblong to oblong, usually small. Petiole short. Venation evident.*

Salix repens, L. (See p. 207.)

†† Catkins flowering early, before the foliage expands, laterally on the twigs, sessile or sub-sessile, with mere scales or only a few young leaves at the base. Scales discolor—i.e. green or pale at the base, tipped with purple-brown to black—ciliate, pubescent, silky or tomentose, and persistent. Both ♂ and ♀ flowers with 1 gland only.

⊙ *Ovary sessile, or at most sub-sessile.*

▱ *Ovary glabrous; style and stigmas long; leaves oblong to oblong-lanceolate; branches pruinose.*

Salix daphnoides, Vill. Violet Willow. Sharply marked by the pruinose deep-purple branches of the second and third years: large shrub.

Catkins lateral on branches of the second year, early, cylindroid, the ♂ abounding in honey, and about 3—5·5 × 1·5—2·5 cm., the ♀ 2·5—5 cm. × 8—12 mm. or so; at first silvery with long, silky hairs, and with few scales at the base. The scales pale below, black in the upper half. Only one posterior gland. Stamens 2, free, glabrous. Ovary sub-sessile, on a pedicel shorter than the gland, glabrous; style long, stigma shortly bifid. Capsule smooth, short, with reflexed valves.

▱▱ *Ovary hairy; branches not pruinose.*

§ *Style short and stigma sessile; ovary white-tomentose; stamen single, of two fused into one; leaves oblong-lanceolate or so, glabrescent, bluish beneath, about 4—6 times long as broad, sub-opposite.*

Salix purpurea, L. Purple Willow (Fig. 62). Branches devoid of waxy bloom.

Catkins lateral on branches of the preceding year, appearing early and flowering just before the leaves unfold, nearly sessile, with a few small basal leaves; slender cylindroid, straight or curved; about 1·5—4·5 cm. long and 5—10 mm. broad. Scales longish obovate or rounded, green below, reddish in the middle, and purple or more generally brown to black at the tips, hairy on both surfaces.

Each flower with 1 very small gland, which is posterior. Stamens of two fused into one up to the anthers, which latter appear as if 4-lobed, purple-red, becoming black; hairy below (Fig. 25, *C*). Ovary on a pedicel shorter than the gland, or sessile; broad, ovoid, blunt, white-tomentose; style very short, or the oblong slender stigmas sessile, and nearly entire; the latter also purple-red, becoming black. Capsules small, sub-sessile, on pedicels not longer than the gland, crowded, tomentose, greenish-white, valves spreading.

[This is one of the narrow-leafed Osier Willows, easily recognised by its single stamen and single gland; leaves sub-opposite and glabrous, or whitish glaucous with mere traces of silky pubescence below, oblong-obovate. Catkins may occur with both ♂ and ♀ flowers.]

Fig. 62. Purple Willow, *Salix purpurea*, p. 216 (Sc).

§§ *Style and stigmas long and slender; ovary silky-pubescent; stamens* 2, *free; leaves narrow linear-lanceolate, silky*

beneath, up to 15—18 *times long as broad, alternate.*

Salix viminalis, L. Osier. The common Osier (Fig. 63), characterised by its very long narrow linear-lanceolate leaves, glabrous above, silky beneath, and with the margins

Fig. 63. Osier, *Salix viminalis*, p. 218 (Sc).

revolute. The ♂ catkins sessile; ♀ nearly so, with a few bracts. Anthers yellow before anthesis. Branches not pruinose.

Catkins sessile, rather crowded, on second year's twigs; appearing early, with a few basal scales only, cylindroid, 1·5—3 cm., the ♂ 12—18 mm., the ♀ 8—14 mm. broad, with long silky hairs appressed to the obovate scales; the latter black or brown at the upper half.

Flowers with only 1 narrow, slender, posterior gland. Male flowers of 2 free, glabrous stamens, yellow, passing to brownish. Ovary sub-sessile, ovoid-conic, appressed silky, with a long glabrous style and deeply divided bifid stigma, both yellow. Capsule sessile or nearly so, ovoid-conic, appressed pubescent, with widely diverging valves.

⊙⊙ *Ovary pedicellate; stamens* 2, *free. Style and stigma rather short.*

▱ *Ovary glabrous, or glabrescent; leaves glabrous or nearly so, blackening when dried, oblong-obovate to nearly rotund,* 2—10 × 1·2—4·5 *cm., with a distinct petiole up to* 2 *cm. long.*

Salix nigricans, Sm. Black Willow. Shrub or bushy tree, with dark brown or olive branches, and leaves which blacken on drying.

Catkins before the foliage, sub-sessile, with leafy bases: the ♂ short oblong, the ♀ long, lax, and slender. Scales oval or oblong, reddish below, deep brown at the tips; covered with long white or rusty hairs. Stamens 2, free, glabrous or slightly hairy at the base. Capsule on a distinct pedicel, glabrous or glabrescent, narrow and tapering, with a long slender style: stigmas bifid, spreading. Nectary very short, not more than $\frac{1}{3}$ the pedicel.

□□ *Ovary hairy; style and stigma short; leaves more or less oblong, ovate, &c., with venation prominent beneath.*

§ *Shoots and leaves tomentose.*

Salix Caprea, var. *cinerea*. Grey Willow. Bushy shrub, with the branches more spreading than in *S. Caprea*, and altogether more pubescent, the buds especially grey-tomentose.

Catkins often more lax, and the scales more velvety. Peduncle of ♀ catkin densely velvety. Stamens much more pubescent at the base. Pollen dark yellow, densely papillate, elongated, 30—35 × 17 μ. In other respects very similar to *S. Caprea* (p. 221).

§§ *Shoots and leaves above glabrescent or glabrous.*

♯ *Leaves glabrous and bluish beneath.*

Salix phylicifolia, L. Tea-leaved Willow. Shrub, with blackening leaves.

Catkins with the foliage, sessile with a few basal scales, ovoid to cylindroid, the ♂ 2—2·5 × 1·2—1·5 cm., the ♀ about 1·5—3·5 × 0·8—1·2 cm. Scales long, lanceolate, distal moiety black or nearly so, dorsal surface hairy. Stamens 2, free, glabrous: anthers yellow, passing to rosy. Ovary ovoid-conic, white-tomentose, with a long style and thick half-bifid stigmas, and on a pedicel shorter than the gland. Capsule hairy, with revolute valves.

[This and *S. nigricans*, Sm., possibly a variety, form two of the most variable and difficult of all our willows. The leaves turn black on drying. They are close to *S. Caprea*.]

♯♯ *Leaves more or less tomentose beneath.*

÷ *Shrub with ovate and often large ovate leaves. Style very short.*

Salix Caprea. Sallow, Goat Willow (Fig. 64). Shrub with grey rugose leaves.

Catkins flowering early, sessile, dense-flowered; very silky (especially the ♂) when young, owing to the scales being covered with long, silky hairs. Scales spathulate, black in the distal half. Male catkins about 3—4·5 × 1·5—2·5cm.; female 1·5—4 × 1·2—2·5 cm. Stamens 2, free, long and radiating, filament glabrous, anthers yellow. Ovary long-conoid, silvery tomentose, on a long pedicel over 3 times as long as the angular gland; style short, stigmas appressed bifid. Capsule narrow, elongated, grey-villous; valves revolute helicoid, pedicel as long as the scale.

[This and *S. aurita* are the common hedge willows, difficult to distinguish, especially as there are intermediate hybrids and varieties. *S. aurita* has typically larger stipules, smaller and more crenate leaves, and is more bushy. *S. cinerea* is more tomentose and ashen grey on its twigs, buds and leaves. The ♂ catkin sessile and with a few bracts; the ♀ sub-sessile and with a few leaves. Monstrous flowers with both stamens and ovules on the carpel occasionally occur.]

÷÷ *Diffuse shrub, with angular shoots and small obovate leaves. Stigma sessile.*

Salix aurita, L. Eared Willow (Fig. 65). Shrub with usually smaller leaves than the Sallow.

Catkins about 0·6—2 cm. long, appearing early, sessile or sub-sessile, with a few short basal leaves. Scales velvety on both faces. The ♂ dense, oblong and extended, with 2 free stamens, very pubescent below: anthers yellow, then brown. The ♀ catkin with a very short villous peduncle. Capsules oval to oblong, conic, tomentose or pubescent, with the pedicel 3—5 times as long as the

Fig. 64. Sallow, *Salix Caprea*.—1, apex of twig with ♂ catkins; 2, a ♂ flower; 3, base of same, showing gland of scale; 4, end of shoot with a ♀ catkin; 5, a ♀ flower; 6, stigma; 7 and 8, capsule closed and open; 9, seed; 10 and 11, buds; 12, leafy shoot, p. 221 (Wi).

gland. Style very short: stigmas short, emarginate, divaricate.

Fig. 65. Eared Willow, *Salix aurita*, p. 221 (Sw).

(β) *Catkin-scales not entire, but slit or fimbriated. Catkins of both* ♂ *and* ♀ *flowers ending the dwarf shoots, and similarly cylindrical, long and pendulous. Flowers borne on, or invested by, a broad and scale-like, or a cup-like disc. The naked* ♂ *flower of about* 8—30 *simple stamens on an oblique open disc; the* ♀ *of a flask-like ovary invested by the cup-like disc. Otherwise like* Salix, *but the leaves as broad as long, or nearly so, and of cordate, rhomboid, or angular outlines, or even lobed; anemophilous* (Populus).

* Stamens about 8; lobes of the stigma linear; catkin-scales velvety-ciliate; shoots and buds pubescent.

† Catkins 50—100 mm. long, scales toothed; stigma yellow; leaves cottony beneath.

Fig. 66. Abele or White Poplar, *Populus alba*, p. 225 (Sc).

Populus alba, L. White Poplar, Abele (Figs. 66, 67). Small tree, with whitish-grey bark, only fully developed below, and white-tomentose twigs and undersides of leaves, the latter varying in shape, ovate, sub-rotate to palmatifid.

Catkins curved, cylindroid, about 4—6 cm. long, on short stalks. Scales obovate-spathulate, unequally toothed,

Fig. 67. White Poplar, showing the variations in form of the leaves, p. 225 (Wi).

membranous, ciliate, yellowish-green with dark brown or purplish tips and margins. Cup-like disc stalked, funnel-shaped with an oblique mouth, brown. Stamens 8—10 with long purple anthers. Ovary glabrous, ovoid-conic, invested

to the middle by the gland; style obsolete, stigmas deeply bifid, the 4 greenish arms spreading crosswise. Capsule stalked, pale brown, glabrous, with reflexed valves.

[The variety *canescens* has the catkins denser; scales obovate-cuneate, more irregularly incised and ciliate anteriorly, bright brown. Stigmas red or greenish.]

†† Catkins 25—50 mm. long, scales laciniate: stigmas more deeply cut; leaves glabrous beneath.

Populus tremula, L. Aspen (Fig. 68). Tree with rounded trembling leaves.

Catkins sub-sessile, dense and silvery tomentose before anthesis, curved; pendent and loose and less woolly later; the ♂ about 6—10 × 2 cm.; fruiting catkin up to 12 cm. Scales dark brown, narrow cuneate at the base, with fan-shaped apex deeply incised into narrow teeth, long-ciliate. Disc shortly stalked with oblique mouth, greenish, half-enveloping the stamens and ovary respectively. Stamens 4—12; anthers purple-red. Ovary stalked; stigmas purple-red, bifid and the arms radiating crosswise. Capsule distinctly stalked, greenish-brown, valves recurved.

** Stamens about 15—30; lobes of the stigma short and angular; catkin-scales glabrous, laciniate; shoots glabrous, buds viscid.

† Capsule ovoid, 2-valved.

Populus nigra, L. Black Poplar (Fig. 69 *a*). Large tree with dark but open foliage, and deeply coarsely fissured blackish bark.

Catkins cylindroid and densely-flowered, the ♂ sessile

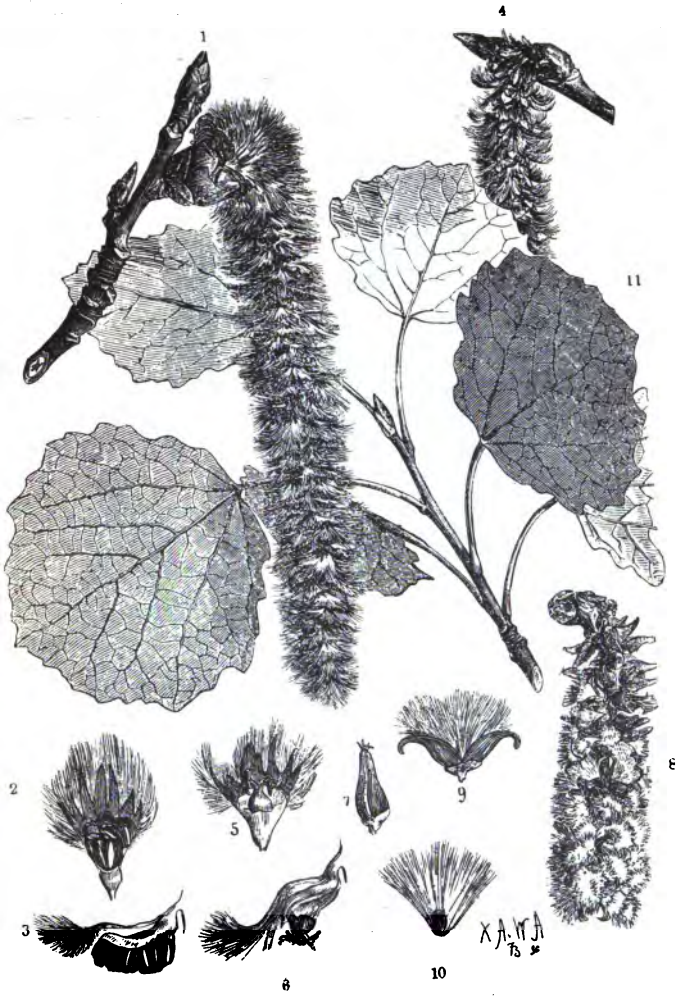


Fig. 68. Aspen, *Populus tremula*. 1, dwarf shoots bearing a ♂ catkin; 2 and 3, ♂ flowers from below and in profile; 4, a ♀ catkin; 5 and 6, flowers from below and in profile; 7, capsule; 8, fruiting catkin; 9, dehiscing capsule; 10, seed; 11, foliage, p. 226 (Wi).

and purple-red before anthesis, up to 7 × 1·2 cm., the ♀ stalked and greenish, up to 10 × 0·8—1 cm., and in fruit up to nearly 13—14 cm. long. Scales membranous, glabrous, greenish-yellow, cuneiform, cut into long purple

Fig. 69. *a*, Black Poplar, *Populus nigra*; *b*, *Populus Canadensis*, p. 226 (Sc).

teeth, caducous. Stamens usually about 8 (6—30) with long white filaments and purple anthers, becoming yellow and then black; scales falling before anthesis. Pollen pale yellow, irregularly polyhedral, warted, 30—40 μ.

Ovary ovoid-conic, glabrous, green, with 4 longitudinal grooves; the disc reaching more than half-way up. Stigmas 2, sessile, yellow, reflexed, irregularly triangular, more or less 3-lobed. Capsule conoid, smooth, olive, stalked, with two widely divaricating valves.

†† Capsule 3—4-valved, globoid.

Populus Canadensis, Desf. Canadian Poplar (Fig. 69*b*). Very like *P. nigra* in foliage, but the crown less spreading.

Catkins glabrous, appearing before the leaves, the ♂ sessile and up to 12 × 1·2 cm., the ♀ stalked and loose, 5 to 8 cm., in fruit up to 25 cm. long. Scales triangular, yellow, incised above and the teeth running into long purple cilia; those of the ♀ catkin very caducous. Stamens 20—30 with red anthers. Ovary stalked, turbinate or sub-globoid, with 4 grooves; stigmas 4 (rarely 3 or 2), sessile, very large and folded and cut into kidney-shaped lobes, and closely reflexed half-way down the ovary, which has 4 placentæ. Stigmas yellowish with purple margins. Fruits stalked, distant, and naked owing to the caducous scales: dehiscing normally by 4 valves.

(ii) Flowers not achlamydeous, but with a greenish perianth; in catkin-like spikes, which are stiff, spreading or erect dwarf shoots.

(*a*) *Flowers sessile at the base of leafy dwarf shoots; perianth segments two. Fruit fleshy, orange spotted with dark points: seed one. Spinescent shrub with silvery or bronze hairs; narrow leaves and no latex.*

Hippophaë rhamnoides, L. Sea Buckthorn (Figs. 70, 71).

A spinescent shrub, with scurf-like peltate silvery or bronze scales, and willowy habit.

Floral formula ♂ P_2A_{2+2} with a large central disc. ♀ $P_2G\,1$. Flowers very small and inconspicuous, in the axils of the lowermost scale-like bracts of the dwarf shoots; the ♂ yellow, each with a perianth of two ligulate lobes and 4 stamens, anemophilous; the ♀ greenish with the perigone densely beset with speltate scales. Ovary of one carpel, containing one seed; stigma erect.

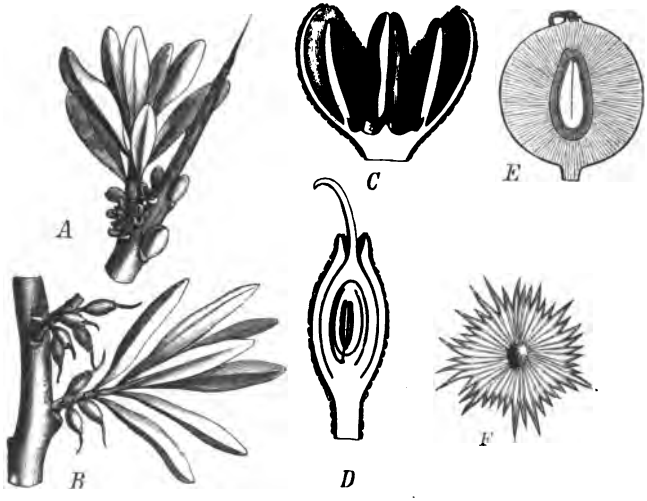


Fig. 70. Sea Buckthorn, *Hippophaë rhamnoides*. *A*, ♂, and *B*, ♀ flowering shoots; *C*, ♂, and *D*, ♀ flower in longitudinal section; *E*, fruit in vertical section; *F*, one of the peltate scales, p. 229 (E and P).

[The only similarly silvery scaled shrub likely to be met with is *Elœagnus*, and it has no spines. Moreover the flowers are hermaphrodite, and in the axils of ordinary leaves.]

Fig. 71. Sea Buckthorn, *Hippophaë rhamnoides*. Fruiting branches, p. 229 (Sc).

(β) *Flowers in short globoid or ovoid spikes. Perianth segments* 4. *Fruit compound, red or nearly black. Plant not spinose or scaly; leaves broad or lobed; juice milky.*

Morus alba, L. The Mulberry though normally

monœcious is occasionally dicœcious, and would then be sought for here. See p. 241.

[Other dicœcious flowers, but with perianths or with calyx and corolla and not in truly catkinate inflorescences, are to be met with in *Rhamnus catharticus* (p. 269), *Viscum album* (p. 264), *Aucuba japonica* (p. 268), *Ruscus aculeatus* (p. 266), *Empetrum nigrum* (p. 267), and *Fraxinus excelsior* (p. 275). As a more or less abnormal state the Holly is also occasionally sub-dicœcious (p. 288) and the same may occur with others.]

(b) Staminate (♂) and pistillate (♀) flowers on the same plant—i.e. monœcious—either in the same or in different inflorescences.

[For (ii) see p. 242.]

(i) Flowers monochlamydeous or achlamydeous; the ♂ with a perianth, the ♀ flowers with or without a minute perigone, but devoid of a cupule. Scales of the catkins not toothed, or slit or fimbriated. The catkins of one sex usually at the ends of long shoots, those of the other terminating the dwarf shoots.

[For (β) see p. 239.]

(*a*) *Both ♂ and ♀ flowers in cylindrical, or ellipsoid, uninterrupted, pendent or spreading catkins, with compound imbricated scales, the ♀ flowers achlamydeous, the ♂ with a perianth* (monochlamydeous). *The catkins, formed in autumn, pass the winter on the tree. Flowers in small dichasia in the axils of the cover-scales, to which the bracts adhere. Anthers glabrous.*

* The ♀ catkins terminating the dwarf shoots 10—15 mm. long; the ♂ at the

end of long shoots 4—5 cm. long; both cylindroid and pendent. Scales tri-lobed, composed of the fused bracteoles and bract. Catkin-scales small and closely imbricated, each bearing in its axil a small group of 3 flowers with bracteoles; the ♂ flowers with free stamens and a perianth (monochlamydeous), the ♀ naked (achlamydeous); fruit a winged samara.

Betula alba, L. Birch (Figs. 72, 73). Tree with monœcious anemophilous flowers, the ♂ in pendent catkins; pendent long thin branches, and white periderm; leaves more or less triangular-ovate and distichous.

Catkins cylindroid, pendent; the ♂ about 3—6 × 0·6—0·8 cm., with brownish scales and yellow anthers; the ♀ about 1—2 × 0·2 cm., olive or yellowish, with purple stigmas, but growing larger (up to 4—8 cm. or more) as the fruits ripen. Scales 3-lobed—i.e. of the cover-scale and two adherent bracteoles—deciduous with the fruits.

The catkin is more complex than in *Salix* and *Populus*, where each scale carries only one naked flower; here the scale subtends a small inflorescence (*dichasium*), in each case a dichasial cyme of three flowers with their bracteoles, which latter fuse with the deciduous catkin-scale, and give to it the compound 3—5-lobed character observed on dissection. Scales red-brown, ciliate; stamens yellow, anthers glabrous.

Each ♂ flower consists of about two minute bract-like perianth segments, enclosing two branched furcate stamens; each ♀ flower consists of a naked flattened ovary with 2 cells, 2 ovules, and 2 stigmas, but ripens to a winged achene. The ♀ catkins, 10—40 up to 60—90 mm. long, terminate the dwarf shoots; the ♂, at the end of the long shoots, pale green, with hairy stalk and ciliate scales.

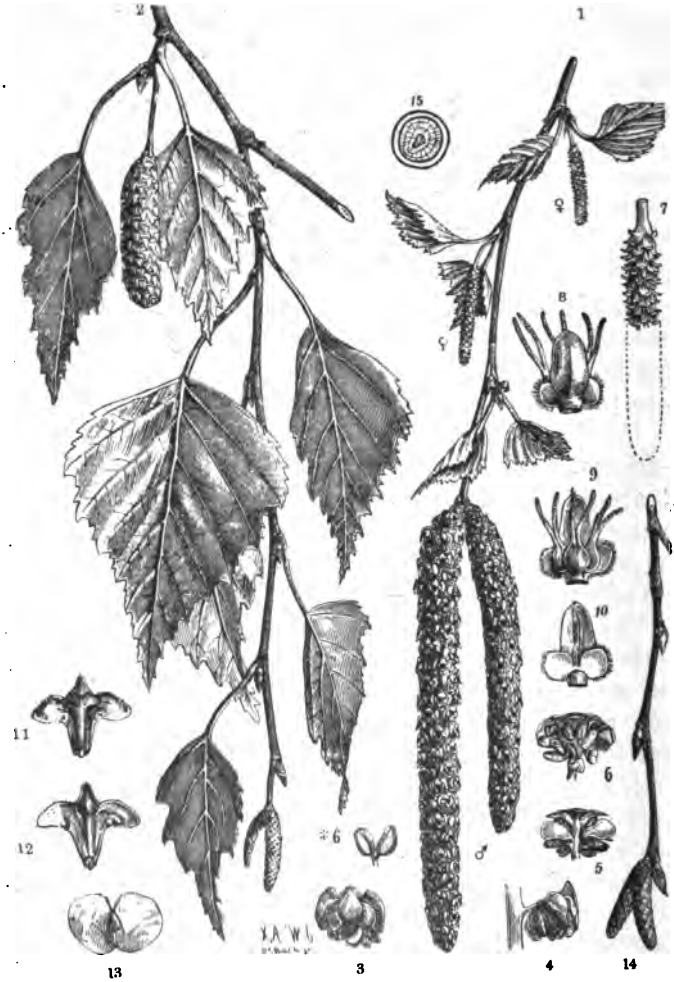


Fig. 72. Birch, *Betula alba*. 1, apex of branch with male (♂) and female (♀) catkins; 2, branch with a fruiting catkin, and, at the tip, young male catkins; 3–6, groups of ♂ flowers in front, lateral, upper and lower aspects; 6*, stamen; 7, portion of ♀ catkin; 8 and 9, groups of ♀ flowers from before and behind; 10, the scales of the latter; 11 and 12, fruiting scales; 13, fruit; 14, apex of shoot with young inflorescences; 15, transverse section of three-year-old branch, p. 233 (Wi).

Stigmas purple-red. Fruiting catkins pendent or not, thick cylindroid, 15—40 cm. long: stalk 7—10 mm. Scales

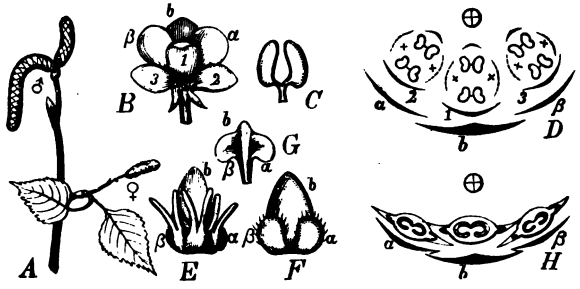


Fig. 73. Birch, *Betula alba*. *A*, shoot with ♂ and ♀ catkins. *B*, bract, bracteoles, and perianth, of ♂, from within, with stamens removed; *C*, a stamen; *D*, floral diagram of *B*; *E*, bract, bracteoles and flowers of ♀, from within; *F*, the same with flowers removed; *G*, the same at ripeness of seed; *H*, floral diagram of *E*. *b*, bract, *α*, *β*, bracteoles of flower 1, or bracts of flowers 2, 3 (Ei).

triple, on a broad short stalk, the lateral angular, hairy and ciliate. The detailed analysis is shown in Fig. 73.

[*Betula verrucosa*, Ehr., is distinguished by some as a species by its more waxy twigs, covered with minute verrucosities; more glabrous leaves and shoots, the former thinner and less leathery, and with longer points; and minor differences in the fruit-scales, &c.

B. nana, L., the Dwarf Birch of the North, is shrubby and bears much smaller catkins, 10—20 mm. or so, with less deciduous scales.]

** Catkins of ♀ flowers ellipsoidal and stiff, stalked, and collected in branched racemose groups of three or four. Scales 5-lobed, becoming woody, and persisting after the fruits fall. The ♂ catkins at length pendulous.

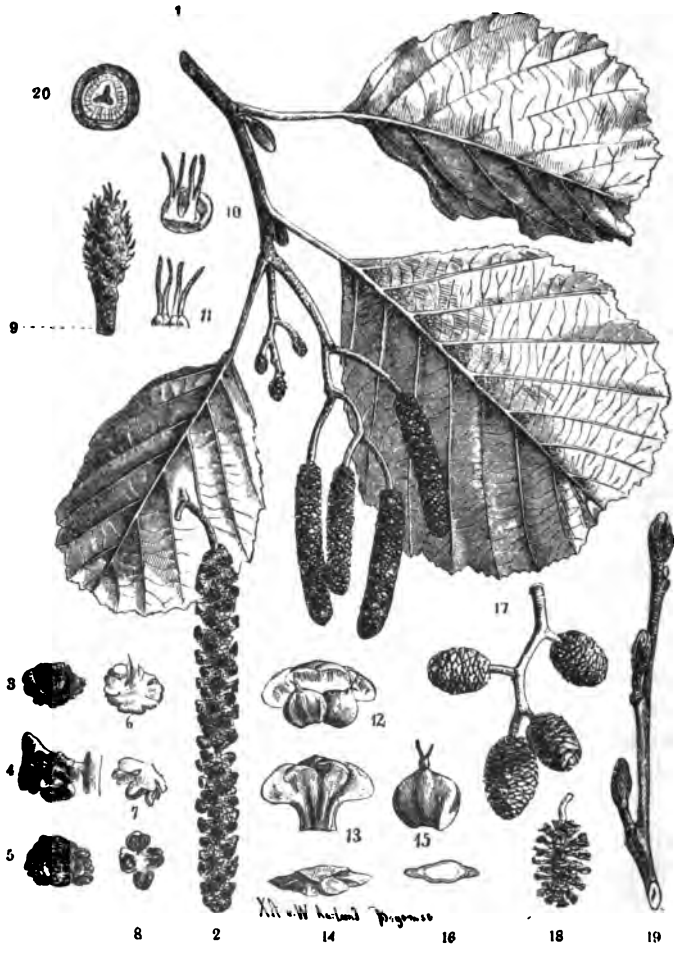


Fig. 74. Alder, *Alnus glutinosa*. 1, flowering shoot with young male and female catkins; 2, a male catkin; 3, one of the scales of the latter bearing three male flowers and their bracteoles, seen from outside; 4, the same in lateral view; 5, the same from inside; 6, the same from above; 7, a single male flower from outside, and 8, from inside; 9, a female

catkin; 10, one of its scales bearing two female flowers, seen separately in 11; 12—14, fruiting scales seen from above, from below and from the front; 15, 16, the fruit whole and in section; 17, ripe cone-like fruiting catkins; 18, one of the cone-like catkins after shedding its fruits; 19, a twig; 20, section of branch, p. 237 (Wi).

[The ♀ catkins in fruit are superficially cone-like. See note, p. 202.]

Alnus glutinosa, L. Alder (Figs. 74, 75). Tree with dark bark and obovate leaves, in three series. Monœcious anemophilous flowers in catkins, on firm, rough stalks.

The ♂ catkins at first stiff, then lax and pendent, violet-brown, 5—6 up to 8—10 cm. long, smooth. Each violet-brown to reddish scale of the ♂ catkin subtends a dichasial group of 3 flowers, each with 4 simple yellow stamens opposite the segments of a 4-lobed perianth, and

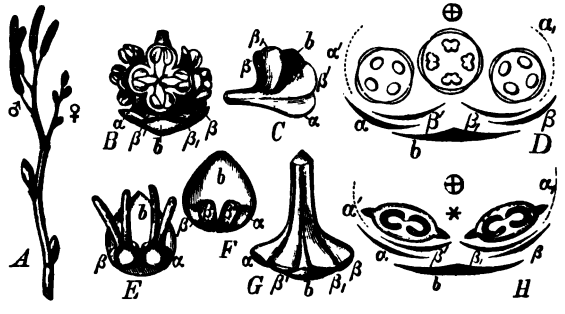


Fig. 75. Alder, *Alnus glutinosa*. *A*, shoot with ♂ and ♀ catkins; *B*, catkin-scale with three ♂ flowers and their bracts α β and bracteoles α' β' seen from above; *C*, the same, without the flowers, seen from the side; *D*, plan-diagram of the same; *E*, catkin-scale with its pair of ♀ flowers and their bracts and bracteoles seen from above; *F*, the same with the flowers removed; *G*, the same fused to form the woody compound scale of the ripe, fruiting catkin; *H*, plan-diagram of *E*. In all, *b* the cover-scale (catkin-scale); α β the bracts; α' β' the bracteoles; * the missing central ♀ flower of the dichasium in *E*; ⊕ axis of catkin (Ei).

4 small bracteoles; all the bracteoles become fused to the scale, making it a complex scale with 5 lappets.

The ♀ catkin 3—4 up to 5—10 mm. long, smooth, with red-brown stigmas; becoming ovoid, stiff, and cone-like, 10—13 mm. long, with sticky resinous wax, passing to smooth. The shield-like end of the scale violet-brown, with a central pale brown point, almost like an apophysis and its umbo. Each scale of the ♀ catkin bears 2 flowers with no perianth (achlamydeous), and consisting of a flat 2-chambered and 2-ovuled ovary with 2 stigmas, ripening to a one-seeded achene, rimmed at the margin. Here, however, the scale, with its fused bracteoles, persists as a dark woody structure, and the ovoid old "cones" are very characteristic in winter. They differ from true cones in having complex scales, in bearing filamentous stamens and simple pollen, and especially in having a perianth to the ♂ flower, and a true ovary with stigmas and enclosed ovules (*angiosperm*).

On comparing the morphological diagram of *Betula* (Fig. 73, p. 235), it will be seen that *Alnus* differs chiefly in having a more complete perianth to each of the ♂ flowers, which are 4-stamened, and in minute points regarding the bracteoles, and in having lost the central flower of the dichasium in the ♀ flower, also with small differences in the bracteoles. Pollen with 5 germ-pores, pale yellow, polyhedral with rounded angles, smooth, about 31 μ.

[The Plane has its monœcious flowers, both ♂ and ♀, in globular heads (capitula), sessile at intervals, on long, pendent stalks; these are not true catkins, however, if only because the flowers are dichlamydeous. The tree is readily distinguished by its large palmate leaves, with buds buried in the bases of the petioles. See p. 273.]

(β) *The ♀ flowers in short tufted or spicate inflorescences; not in pendent catkins.*

* The ♂ flowers in cylindroid, uninterrupted, pendent catkins, which are sessile at the base of the young shoots: each scale bears about 10—20 stamens surrounded by about three perianth segments, subtended by a couple of bracteoles, all fusing with the scale, like lappets. The ♀ flowers in short, stiff, erect spikes of 2—3 or more, and terminating the current shoots. Each flower of the ♀ catkin subtended by a small double scale (bracteole) which fuses with it below.

Juglans regia, L. Walnut (Fig. 76). Large tree, with grey bark and pinnate leaves, aromatic, and with chambered pith; flowers monœcious and anemophilous.

Male catkins sessile and pendent at the base of the young shoots, developed from buds of the preceding summer; dense-flowered, greenish, cylindric, 10—15 × 2 cm. The ♂ flower consists of about 10—20 (6—40) stamens, fewer in the upper, more in the lower, with 2—5 perianth leaves, and 2 bracteoles, all adnate to the bract (catkin-scale) and with no trace of ovary. Female flowers in groups of 2—3 or more (rarely up to 15—20 or more), in spikes terminating the current year's shoots; green, with purplish stigmas: anemophilous.

The ♀ flower consists of a 1-celled ovary of two carpels with epigynous and adherent 4-lobed perigone, and 2 fused lateral bracteoles, subtended by the bract (catkin-scale). Ovule 1, basal, straight. Stigmas 2, blunt, papillose. Fruit drupaceous, sub-globose, pointed, green with glandular dots, darkening to brown when bruised,

glabrous, about 4—6 cm. in diameter and dehiscing irregularly. Pollen nearly white, irregularly polyhedral, beset with numerous minute warts: up to 50 μ in diameter.

The ♂ catkins are dwarf shoots in the axils of leaves

Fig. 76. Walnut, *Juglans regia*. 1, flowering shoot, bearing *a* a male catkin and *b* a female inflorescence; 2, male flower with *a* a stamen seen from within, *b* one from the side; 3, female flower; 4, vertical section of same; 5, fruit with one half removed; 6, vertical section through the nut; 2, 3 and 4 enlarged, p. 239 (Wo).

on last year's twigs; the ♂ flowers sessile at the apex of the new shoots. In the ♂ flower the perianth segments vary from 2—5, and the stamens from about 5—20.

** Both ♂ and ♀ flowers in stiff, short, ovoid, erect or spreading spikes, which are 1—4 cm. long at most; the ♂ spikes nearer the apex of the shoot. Tissues not fragrant, but with milky juice: pith not chambered.

Morus alba, L. Mulberry (Fig. 77). Small tree,

Fig. 77. Mulberry, *Morus alba*. 1, a male, and 2, a female flowering shoot; 3, male, and 4, female flower, enlarged; 5, the latter in vertical section; 6, the multiple fruit, p. 241 (Wo).

with variable leaves and milky juice, monœcious or, rarely, dicœcious, anemophilous.

Flowers small, green, in short, catkin-like pseudo-spikes of cymes; axillary on the dwarf shoots. The ♂ on the same branches as the ♀ (and then near the apex of the shoot) or not; the ♀ at the base of the shoot. Male spikes 2—4 cm. long, ovoid and catkin-like. Perianth 4-partite, yellowish-green; stamens 4, long, exserted. Pollen floury, white, irregularly tetrahedral, 20—25 μ. Female inflorescence pedunculate, sub-globose or oblong, about 1—1·5 cm. Perigone 4-partite, greenish; ovary subsessile, with short style and two thick spreading stigmas. Ovule 1. Fruit false berried and multiple, globoid or oblong, up to 1·5 cm., the perigone becoming fleshy and enclosing the achenes, and all fusing into the Mulberry, red, sweet.

[The Black Mulberry differs somewhat in its leaves, is more dicœcious, and has shorter peduncles and larger black mulberries.]

(ii) Each ♀ flower, or group of two or three flowers, surrounded at the base by a leafy, or tough and thick cupule, in addition to the adherent epigynous perigone.

[For (β) see p. 246.]

(*a*) *The ♂ catkins long, cylindroid, uninterrupted and pendulous. Cupule leafy and membranous, not prickly or scaly.*

* The ♂ catkins at the ends of dwarf shoots; the ♀ terminal on the long shoots. Scales loosely imbricated; those of the ♀ especially large, and fusing with the two lateral bracteoles to a large tri-lobed leafy appendage which wraps round the two ♀ flowers at their base, forming an

adherent, wing-like, incomplete cupule to the nut-like fruits.

Carpinus Betulus, L. Hornbeam (Figs. 78, 79). Medium tree, with Beech-like habit and smooth Beech-like but fluted stem, and dull, somewhat Elm-like leaves, and large rosy stipules on the young shoots. Monœcious, anemophilous flowers.

Male catkins tawny, numerous, 3—4 cm. long, representing dwarf shoots, and developed in spring; scales broad ovate, acute, entire, veined longitudinally, and ciliate; yellowish-green, with reddened tips.

Each scale bears on its inner face a naked ♂ flower, consisting of about 8—10 (4—12) stamens, split nearly to the base, with long yellow ovoid anthers, hairy at their tips, and with no bracteoles. Pollen pale yellowish, irregularly polyhedral, papillose, with 3 pores, about 50 μ in diameter.

Female catkins fewer, terminating the long shoots, about 2 cm. long, pale green, loose, and with small deciduous bracts and bracteoles in the cover-scales.

Scales ovate-acuminate, long-ciliate. Each cover-scale bears two collateral ♀ flowers (dichasium), which, like the scales, are covered with long white hairs. There are 6 subtending bracteoles, and each ♀ flower consists of a 2-celled ovary, with one ovule in each cell, surmounted by a minute epigynous perigone, and two red stigmas.

Fruiting catkins loose and pendent, about 8 cm. long, on a stalk of nearly equal length. Fruit 1-seeded and nut-like, ribbed, crowned by the angular, toothed perigone, and remains of the stigmas; and winged with a large tri-lobed foliaceous appendage (cupule) 3—4 cm. long, composed of the fused and enlarged, prominently-veined bract and bracteoles, the catkin-scales having fallen off.

Fig. 78. Hornbeam, *Carpinus Betulus*. 1, flowering shoot with two male catkins below and a female catkin above; 2, a fruiting catkin;

3, scale of male catkin from in front; 4, the same from the side, and 5 from inside, showing the stamens, of which two are also seen separated and viewed from behind and from the front; 6 and 7, pair of female flowers enveloped in their bracts and bracteoles; 8, a separated female flower; 9, fruits and cupule; 10, fruits; 11, the fruit in section; 12, seeds; 13, buds; 14, seedling.

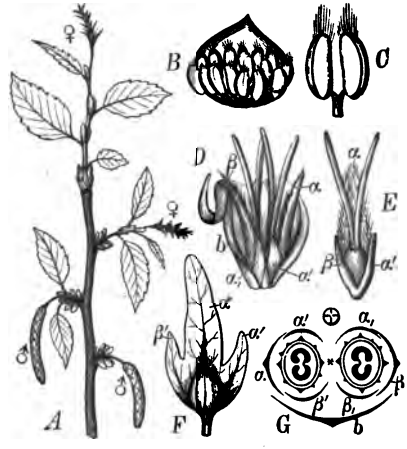


Fig. 79. Hornbeam, *Carpinus Betulus*. *A*, shoot bearing ♂ and ♀ catkins. *B*, cover-scale (catkin-scale) with its ♂ flower seen from within; *C*, a stamen; *D*, cover-scale (catkin-scale) with its pair of ♀ flowers, from within; *E*, a ♀ flower with its bract *α* and bracteoles *α' β'*; *F*, the same ripened to a fruit, and the bract and bracteoles fused to form the wing (cupule); *G*, plan-diagram of *D*; ⊕ axis of catkin; * missing central flower of the dichasium. In all, *b* cover-scale; *α β* bracts; *α' β'* bracteoles (Ei).

** The ♂ catkins long, pendulous, cylindrical, uninterrupted, and with closely imbricated scales; terminating axillary shoots of the previous year. They are formed in the late summer, and hang throughout the winter to open very early in spring. The ♀ flowers in bud-like, sessile, axillary

spikes, from between the upper scales of which the paired red stigmas project in early spring.

Corylus Avellana, L. Hazel (Figs. 80, 81). Bush or shrub, with broad, rather Elm-like leaves, but glandular hairy shoots, bearing long pendent ♂ catkins in winter and early spring. Monœcious, anemophilous.

Male catkins 2—3 up to 5 cm. long, at length dangling; scales pale brown, hairy, each bearing on its inner face 2 adnate bracteoles flanking a group of 4 yellow stamens, each bifid to near its base; anthers tufted with hairs. This group is the male flower. The adnate bracteoles form two minute lappets to the scale. Pollen sulphur-yellow, tetrahedral, smooth, about 31μ in diameter, with 3 germ-pores.

Female flowers in an ovoid bud-like spike, a few mm. long, consisting of a number of barren scales (stipular) below, investing a few similar scales with leaf-rudiments, and within these come 4—8 scales, each with two ♀ flowers in its axil. In spring the long red stigmas project between the scales (Fig. 80, 1, ♀) and thus the catkin is distinguished from an ordinary leaf-bud. Each ♀ flower consists of a minute two-chambered ovary, with one ovule in each chamber. There is a trace of an adherent epigynous perigone, and the whole is invested at the base by a bract and two bracteoles, which fuse to form the fimbriated, membranous cupule or "husk," as the fruit ripens to the well-known nut. The perigone is easily detected on fresh filberts as a slightly fimbriate rim below the apex of the nut. The catkins are terminal on dwarf shoots.

(β) *The ♂ catkins not cylindroid, nor with closely imbricated and uninterrupted scales. Cupule thick, tough and leathery or nearly woody; scaly, or prickly, &c.*

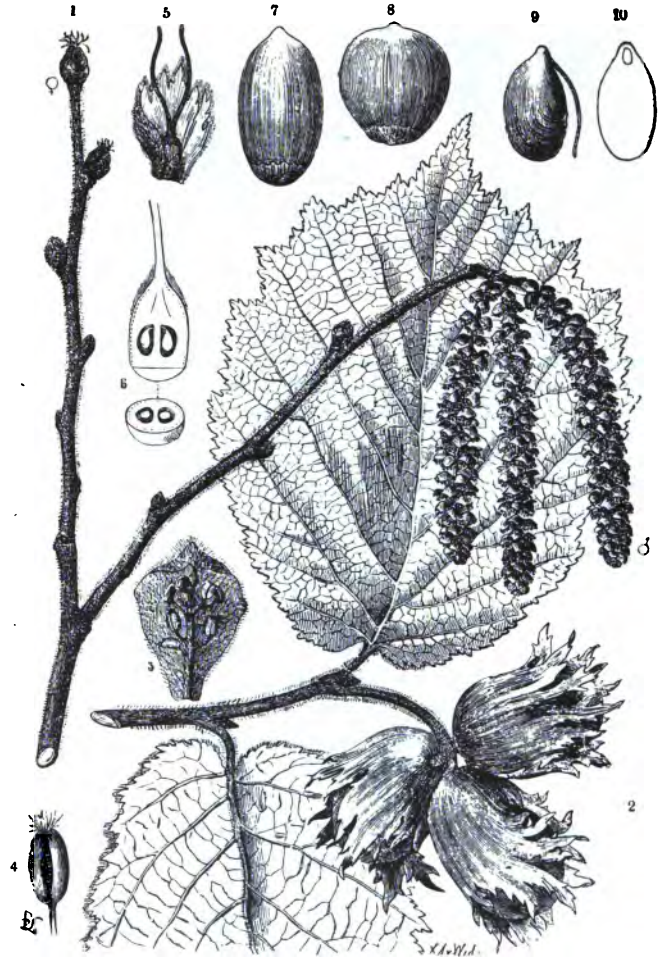


Fig. 80. Hazel, *Corylus Avellana*. 1, twig with ♂ and ♀ flowers; 2, leaf and nearly ripe fruits; 3, scale, bearing ♂ flower; 4, a stamen; 5, female flower invested by the young involucre; 6, sections through ovary; 7, 8, nuts; 9, 10, kernel (embryo), p. 246 (Wi).

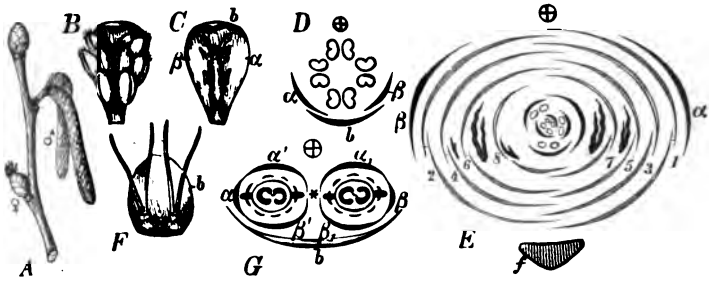


Fig. 81. Hazel, *Corylus Avellana*. *A*, twig with ♂ and ♀ inflorescences; *B*, cover-scale with ♂ flower, from within; *C*, the same with the anthers removed to show the two bracts α and β; *D*, floral diagram of same; *E*, plan-diagram of ♀ flowering shoot; *f* leaf-scar in the axil of which the shoot is borne; α and β bracts; 1—8 pairs of stipules (bud-scales), the inner of which have their corresponding leaves; in the centre five ♀ flowers; ⊕ shoot-axis; *F*, a cover-scale with its pair of ♀ flowers; *G*, plan-diagram of ♀ inflorescence; * the missing central flower of the dichasium; ⊕ axis of catkin. In all, *b* is the cover-scale; α and β bracts; α′ and β′ bracteoles, p. 246 (Ei).

* The ♂ flowers in sessile tufts on stiff and outstanding, long, slender spikes, with a few triple groups of ♀ flowers at the base of some of them. Each group of three ♀ flowers completely invested in a prickly cupule.

Castanea vesca, L. Chestnut (Figs. 82, 83, 84). Large tree, with lanceolate serrate leaves and monœcious pollen-flowers, and at least in part entomophilous.

Spicate catkins single, axillary, often numerous, 12—21 cm. long, stiff, erect, cylindroid. ♂ flowers in dichasia of 3—7 in the axil of the bract, and surrounded by minute bracteoles; each flower with about 9—12 long stamens and a rudimentary pistil, enclosed in a 6-lobed perianth;

yellowish-white to yellow. Pollen coherent in balls; each grain elongated, about 19 × 8 μ, smooth, with three long

Fig. 82. Chestnut, *Castanea vesca*. Shoot bearing ♂ and spikes with ♂ and ♀ inflorescences, p. 248 (Ba).

folds. The ♀ flowers green, with reddish stigmas, singly or in threes, each group invested by a large hairy and prickly cupule, and bracts, the group up to 9—10 cm. diameter. Ovary inferior, with about 6 cells, each containing 2 ovules, and surmounted by a 6-lobed perianth and 6 stigmas.

Fig. 83. Chestnut, *Castanea vesca*. 1, flowering shoot; 2, vertical section through cluster of female flowers in their involucre; 3, transverse section of ovary; 4, a male flower; 5, fruits in their involucre, p. 248 (Wo).

As the fruit ripens, all the cells and ovules but one abort, the result being the round-angled brown chestnut

enveloped in its prickly cupule; when this contains three "nuts," each is the result of a ♀ flower. The cupule, at first rather hairy than spinose, gradually stiffens

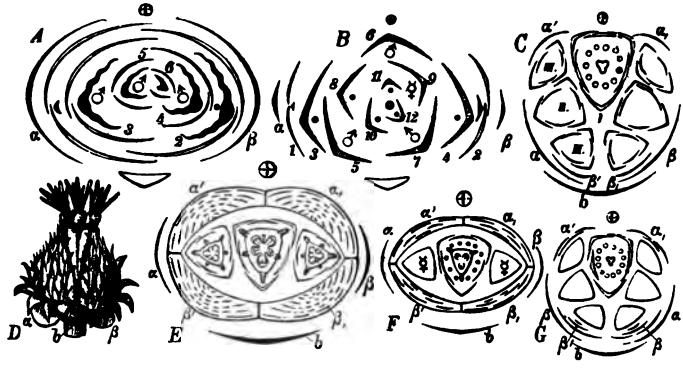


Fig. 84. Analysis of flowers of Chestnut, *Castanea vesca*. *A*, plan of bud, bearing distichous leaves and male inflorescence; *B*, of one bearing spiral leaves and flowers of both sexes (the stipules of leaves 3—12 left out); *C*, diagram of a group of male flowers, stamens and rudiment of pistil only in the larger primary flower; *D*, a group of female flowers; *E*, plan-diagram of same; *F* and *G*, ditto of groups transitional between *C* and *E*, occasionally met with. In all, ⊕ axis; *b*, cover-scale; *α*, *β*, bracts; *α′*, *β′*, bracteoles, p. 248 (Ei).

the pointed greenish spines, which then diverge and radiate like porcupine quills, and the whole cupule splits into four valves. Fruit, the chestnut, ovoid to plano-convex or compressed, dark shining red-brown, with large grey stigmas; 2—3·5 cm. long.

For the morphology of the inflorescence and flowers see Fig. 84. Each cluster of ♀ flowers consists normally of a dichasium of three inferior, 6-celled ovaries, each cell with 2 ovules; each ovary is surmounted by a scaly epigynous perianth, and 6 stigmas—or the number 5 may prevail—and the whole dichasium is invested by the

cupule, and subtended by an anterior bract and 2 lateral bracteoles. The occasional occurrence of mixed groups and of hermaphrodite flowers is noteworthy.

[The student may compare the more coarsely prickly "husk" of the Horse-chestnut, which is the ovary—the "nuts" being the true seeds—with what is here described.]

** Staminate and pistillate flowers on the same tree, on different inflorescences, which are never stiff spikes; cupule of ♀ flowers enclosing 1 or 2 but not 3 flowers.

† The ♂ flowers aggregated into a tassel-like head, at the end of a long and slender pendulous stalk; ♀ flowers in pairs totally invested by a tough cupule, densely covered with subulate, hardly prickly, outgrowths; at the end of a short stiff stalk. Nuts trigonal with sharp angles, set free by the splitting into 4 valves of the prickly cupule.

Fagus sylvatica, L. Beech (Figs. 85, 86, 87). Large tree with cylindrical smooth stem and dense shade of foliage. Inflorescences on the young wood, proterogynous; flowers monœcious, anemophilous.

Male flowers in sub-globose, tassel-like, cymose heads, pendent on long (5—6 cm.) slender silky stalks; ♂ flowers numerous, yellowish to orange, white-pubescent. Anthers yellow. Perianth lobes 4—7; stamens 8—12. Pollen ellipsoid, with 3 longitudinal furrows. Female flowers in close erect groups, greenish, hairy, with prominent purplish-red stigmas. Each ♀ inflorescence is a dichasium of 2 flowers, on a short thick erect stalk, and consists of an ovary with 3 stigmas invested in a 4—6-lobed perigone. Fruit ovoid-trigonal, acute, shining red-brown, about 16 mm. long. Cupule stalked, tomentose and subulate-spinose, woody

Fig. 85. Beech, *Fagus sylvatica*. 1, shoot with a group of ♀ flowers above, and ♂ catkins below; 2, a male flower; 3, stamens, and trans-

verse section of anther; 4, two female flowers in their cupule; 5, ovary, advancing towards maturity; 6 and 7, the same in section; 8, fruits exposed by the splitting of the cupule into four valves; 9, the same before splitting; 10, seed in section; 11 and 12, buds, p. 252 (Wi).

Fig. 86. Beech, *Fagus sylvatica*. 3, vertical section through female inflorescence; 5, ripe fruit showing between the valves of the cupule, p. 252 (Wo).

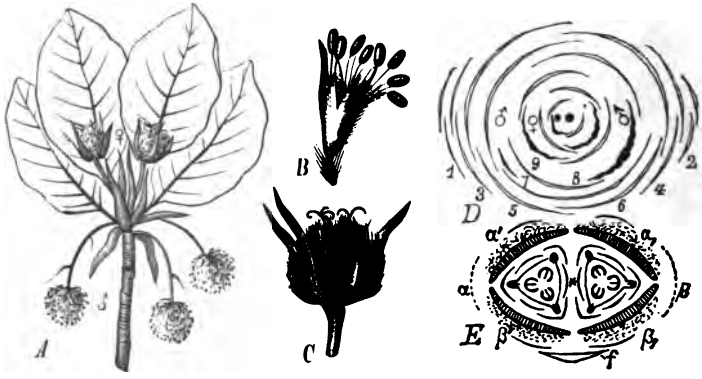


Fig. 87. Beech, *Fagus sylvatica*. *A*, a terminal shoot with ♂ and ♀ inflorescences; *B*, a ♂ flower; *C*, a ♀ partial inflorescence; *D*, plan-diagram of a flowering terminal shoot in bud; 1—9 the stipular bud-scales, the inner of which have their corresponding leaves. The innermost leaves bear ♂ or ♀ inflorescences in the axils; *E*, plan-diagram of *C*; *f* cover-scale; *α β* bracts; *α' β'* bracteoles subtending the four-lobed cupule which encloses the two ♀ flowers; * the missing central flower of the dichasium, p. 252 (Ei).

and tough, reddish-brown. Each ♂ flower consists of a bell-shaped, irregularly 5—6-toothed, pubescent perianth, with 8—12 exserted stamens. Each ♀ flower consists of a trigonal ovary, with 3 chambers, each containing 2 ovules, and a trifid stigma projecting beyond the epigynous 4—6-lobed perigone. The cupule closes in over each pair of flowers, and enlarges with the fruit, at length becoming hard and thick and splitting regularly into 4 valves. Seed 1, with curiously folded cotyledons.

†† The ♂ flowers isolated and sessile, at intervals along a thin pendulous stalk; ♀ flowers each invested at the base, and singly, by a cup-like scaly cupule, from which it protrudes; in sessile or stalked groups. Fruit a more or less ovoid nut (*Quercus*).

[Each ♂ flower is composed of a spreading perianth, not very conspicuous, of about 5—7 lobes, with 4—12 short stamens, and arises from the axil of a subtending bract. There is no trace of an ovary. Each ♀ flower consists of a rounded 3-celled ovary, with 2 ovules in each cell, and more or less flattened styles, bearing stigmatic surface above; the whole in an investing perigone with about 6 teeth, and surrounded at the base by the solid scaly cup-shaped cupule. The ripe nut (acorn) contains 1 large seed, with fleshy cotyledons, its apex projecting more or less: within the shell may be found the starved remains of the aborted seeds. Flowers monœcious and anemophilous; proterogynous.]

⊙ *Stigmatic arms much shorter than the rest of the flower with its cupule stumpy and smooth; cupule scales closely appressed, grey; shell of acorn thin and with no remains of septa.*

[For (⊙⊙) see p. 260.]

[For (▱▱) see p. 260.]

▱ *Acorn smooth and polished; leaves deciduous, hardly coriaceous, sinuate-lobed* (*Q. Robur*).

Quercus Robur, L. The Oak (Figs. 88, 89, 90). Large spreading tree, with tortuous branches and obovate-oblong, sinuately-lobed deciduous leaves.

Male catkins pendent, 2—4 cm. long, breaking singly from lower axils of shoots, but often in tufts, owing to their breaking out from buds on twigs of the previous year; flowers distant, each with a 6-partite, yellowish-green, ciliate perianth, about 7—8 (4—12) sulphur-yellow stamens. Female flowers in groups of 1—5 (or rarely up to 10), inserted singly on the sides and apex of short or long stalks, developed in the axils of the uppermost leaves of the shoot. Each flower consisting of an ovoid 3-celled ovary, invested by a reddish scaly velvety cupule, and surrounded by a minute perigone, and bearing three short, spreading, broadening and round-ended red stigmas, sometimes squat and lobe-like.

Acorns varying in form and size, 1—5 (often 2), on a stiff, smooth or velvety stalk, 1—16 cm. long, or sessile in the leaf axils; each about 2—3 cm. long (15—50 × 10—22 mm.), smooth and polished except at the puberulent apex, longitudinally striate above, pale brown to leather-tawny, and usually about twice as long as the cupule, though sometimes much longer. Cupule scales densely imbricate, triangular ovate, and suddenly pointed, very numerous and small, velvety. The aborted seeds may be found in the lower part of the shell.

[Two principal varieties are distinguished, *Q. pedunculata* (Fig. 88), with the acorns scattered and on evident stalks, shoots glabrous, and the leaves glabrous and subsessile; and *Q. sessiliflora* (Fig. 89), with sessile and

Fig. 88. Pedunculate Oak, *Quercus Robur*, var. *Pedunculata*. 1, flowering shoot; 2, apex of branch with pedunculate acorns; 3, portion of ♂ catkin; 4, stamen, and 5, transverse section of anther; 6, female flower; 7, the same in section; 8, twig with buds, p. 256 (Wi).

more crowded acorns, downy twigs, and petiolate leaves, glabrous beneath. The acorns are often fewer (1—3), but

Fig. 89. Sessile-flowered Oak, *Quercus Robur*, var. *sessiliflora*. 1, flowering shoot, the ♀ flowers in the uppermost leaf-axils; 2, apex of branch with the sessile acorns; 3, a female flower; 4, portion of ♂ catkin, p. 256 (Wi).

may be seven, and less striate. These, and other varietal forms, e.g. *Q. pubescens*, with more pubescent leaves, peduncles, and cups, all pass one into the other.

The morphology of the ♀ flower (Fig. 90) may be best understood by comparison with that of the Beech (Fig. 87), and Chestnut (Fig. 84). Each cupule in *Quercus* invests an inflorescence composed of one flower only—corresponding to the central one of the three found in *Castanea*, and to

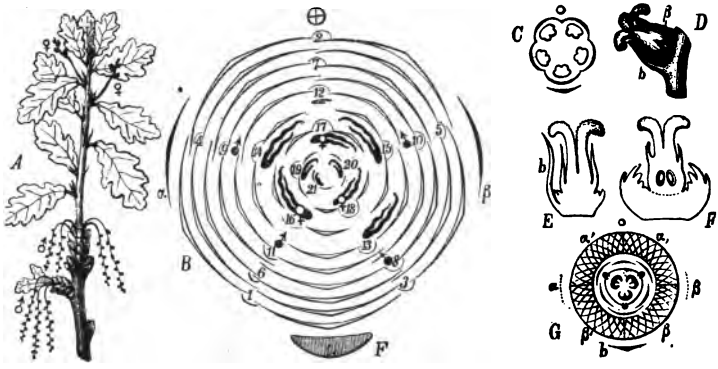


Fig. 90. Analysis of floral parts of Oak. *A*, inflorescence of *Quercus Robur*, ♂ male and ♀ female. *B*, plan of a lateral bud bearing leaves and flowers of *Q. palustris*; *C*, floral diagram of male flower; *D*, a female flower of same; *E* and *F*, longitudinal section of female flower of *Q. Robur*, and *G*, its floral diagram. In all figures, *b* bract, *α* and *β* bracteoles, and the numbers in *B* are placed in the position of the leaf belonging to each pair of stipules, p. 256 (Ei).

the one which is missing in *Fagus*. This flower, invested by its cupule, is subtended by a bract (Fig. 90, *B* and *E b*), and consists of a tricarpellary inferior ovary, with two ovules in each loculus, only one of which usually becomes a seed. Remains of other cells and ovules can often be found at the base on dissecting the 1-seeded and 1-celled acorn.]

□□ *Acorn velvety above; leaves entire or spinose-dentate and persistent.*

Quercus Ilex, L. Evergreen Oak, Holme Oak. Small evergreen tree with greyish-green foliage, the leaves often spinose-toothed like Holly.

Male catkins 4—6 cm. long, with distant flowers, each with a 6-partite perianth, whitish-tomentose, as is also the rachis. Anthers tipped with a short point. Female flowers in raceme-like groups, on tomentose stalks about as long as the leaves; ovary and cupule grey-tomentose. Stigmatic arms short, broad and blunt, sessile, reflexed. Acorns sessile on the long sinuous or zigzag stalks, up to 3·5 cm. long. Cupule hemispherical, of densely imbricate, ovate-lanceolate, tomentose scales. Very variable in shape and size, pale brown, smooth, acute. The aborted seeds occur in the lower part of the shell.

⊙⊙ *Stigmatic arms elongated, linear and style-like; at least as long as the rest of the flower and its cupule.*

□ *Scales of cupule numerous and small, triangular ovate, appressed and closely imbricate, with broad bases. Shell of acorn thick, with remains of septa below. Leaves deciduous, thin, and with pointed lobes. The ♀ inflorescences and buds not invested by persistent subulate stipules. Aborted seeds in the upper part of the acorn. Acorns in shallow or turbinate cups.*

§ *Cupule, even in the flower, very shallow and embracing the very base only. Acorn projecting $\frac{1}{2}$ to $\frac{5}{6}$ of its length.*

Quercus rubra, L. Red Oak. Small tree, with broad, thin, acutely-lobed leaves, turning bright red in autumn.

Acorns single and sessile, in the axils of fallen leaves; long ovoid, more or less cylindroid above, polished brown. Cupule hemispherical, smooth, with small ovate, closely-appressed scales.

§§ *Cupule, even in flower, investing more than half-way up. Acorn projecting about ⅓ to ½ its length.*

Quercus coccinea, Wangenh. Scarlet Oak. Very like *Q. rubra* in habit and foliage, but leaves more deeply divided, and brighter scarlet in autumn.

Acorn in a stalked and more urceolate cupule, investing the globoid-ovoid nut more than half-way up.

□□ *Scales of cupule elongated and subulate, more or less reflexed or spreading, giving the cup a mossed appearance; acorn thin-shelled, long and slender, rough. Aborted seeds in the lower part of the acorn.*

§ *Leaves hardly coriaceous, sinuate-lobed, green both sides; buds fringed with persistent stipules.*

Quercus Cerris, L. Turkey Oak, Mossy-cupped Oak (Fig. 91). Fairly large tree, easily known by the subulate persistent stipules investing the buds and leaf-scars, the pinnate angular-lobed leaves, and "mossy-cupped" acorns.

Male catkins about 7—8 cm. long, with very distant flowers, on a tomentose axis. Perianth usually 4-partite, tomentose outside, with 4 yellow hairy stamens. Pollen ellipsoid-oblong, with 3 longitudinal furrows. Female flowers sessile, and single or grouped in 2—4, on short, thick, axillary peduncles, the bracts and ovaries grey-tomentose; stigmatic arms often 4, sessile and reflexed, linear and pointed.

Fruit ripening the second year, single or grouped, on stalks 10—27 mm. long. Cupule urceolate, 1—1·5 cm. deep, and about 3·5 cm. in diameter, densely covered with

Fig. 91. Turkey Oak, *Quercus Cerris*, p. 261 (Sc).

subulate, stiff or curled, rounded, brown-tomentose, in part recurved and pointed scales, from which the name

"Mossy-cupped Oak" is derived. Nut long ovoid, dark brown, tomentose at the pointed end, but smooth below, about 3 cm. long. Abortive seeds in the lower part of the shell.

§§ *Leaves coriaceous, persistent, entire or spinose-dentate, whitish below; cup-scales longer and more erect on upper parts, reflexed below, soft.*

Quercus Suber, L. Cork Oak. Small evergreen tree, with leathery leaves, somewhat like those of *Q. Ilex*, but more tomentose beneath.

Male catkins loose-flowered, numerous, tufted, up to 4 cm. long, the axis grey-tomentose; perianth 6-partite, on long pedicels, reddish-tomentose outside, and bearing short stamens with ovoid-acute anthers. Female flowers white-tomentose, single or grouped, sessile on an axillary tomentose rachis, each with 3—4 broad, linear, sessile reflexed stigmatic arms. Cupular scales rather few and very hairy in flower. Fruits 1·5—4 cm. long, sub-sessile, narrow, cylindric oblong. Cupule hemispherical or top-shaped, with loose grey-tomentose scales; nut 2—3 times as long as the cup, varying in shape, acute, polished pale brown. The upper scales of the cupule may be rather long and nearly subulate, erect or spreading; the lower more triangular and imbricate.

[Other plants with monœcious flowers are the Plane (p. 273), the Box (p. 271), and the Fig (p. 271); but the Plane has dichlamydeous flowers in capitula sessile, on pendent stalks, not truly catkinate, and the inflorescences of the Box and the Fig are not catkins.]

(2) Inflorescence not a true catkin, or catkin-like spike.

[For (b) see p. 270.]

(a) The ♂ and ♀ inflorescences on different plants—i.e. "dicecious."

(i) Flowers devoid of both calyx and corolla—i.e. achlamydeous; stamens two; ovary of two carpels. Inflorescence a densely crowded panicle of decussate racemes, each with a terminal flower.

Fraxinus excelsior, L. Ash. A large tree with opposite pinnate leaves. The flowers show all stages of polygamy, and are occasionally dicœcious, when they may come here. See p. 275.

(ii) Flowers with a perianth—i.e. monochlamydeous—or with calyx and corolla—i.e. dichlamydeous.

(*a*) *Perianth single, or at any rate not distinguishable into calyx and corolla—i.e. the flower is monochlamydeous. Flowers yellow-green in dense sessile clusters in the forks of apparently dichotomous shoots. Evergreen parasite.*

Viscum album, L. Mistletoe (Figs. 92, 93). Yellowish-green parasitic shrub, with pseudo-dichotomous (dichasial) branching, and dicœcious flowers with exposed honey.

Flowers yellow-green, small, in dense sessile cymose clusters of 3 (or 2 or 5) between the forks of the dichasial shoots, the males the larger. Perianth segments 4 or 6. Stamens 4 or 6 with numerous pollen-sacs sessile and fused on them and to the perianth-segments, the latter on the margin of a hollowed-out receptacle. Floral

formula ♂ P_{2+2} or $_{3+3}$ A_{2+2} or $_{3+3}$; ♀ $P\,2+2\;G\overline{(2)}$. Pollen sulphur-yellow, oval, finely papillate, and adherent. Ovary of 2 carpels, syncarpous and inferior, one-celled, sunk in

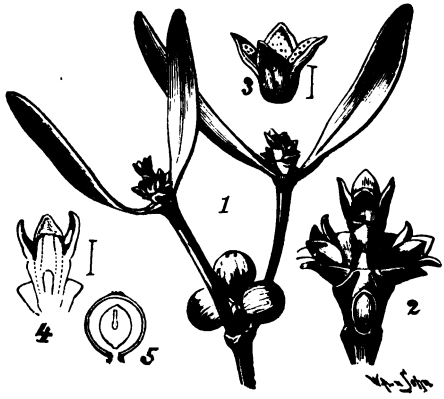


Fig. 92. Mistletoe, *Viscum album*. 1, shoot of female plant, bearing flowers and fruit; 2, group of flowers; 3, a male flower; 4, section of flower; 5, section of fruit, p. 264 (Wo).

the receptacle and fused with it; with one immersed ovule. The stigma thick and blunt. Entomophilous.

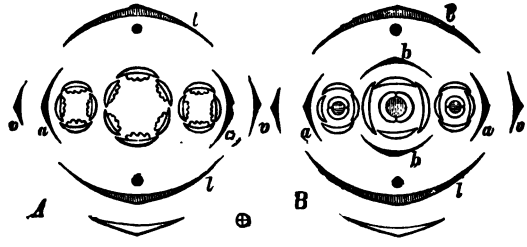


Fig. 93. *A*, plan-diagram of ♂ flowering shoot of Mistletoe, *Viscum album*; *B*, the same of a ♀ shoot and flowers. *v* bracts; *l* leaves with shoots in their axils; *a* and *b* bracteoles of the inflorescence. Each ♂ flower shows four or six perianth-segments bearing fused anthers; each ♀ flower four perigone-segments around the ovary, p. 264 (Ei).

Fruit a white pseudo-berry, the very viscid flesh being that of the receptacle. The viscin of the fruit prevents birds from swallowing the seed, which they therefore rub off on to branches while cleaning the beak: the seed is then washed into a crevice by rain, and germinates.

(β) *Perianth double, the outer series representing a calyx, the inner a corolla.*

* Outer (sepals) and inner (petals) segments of the homochlamydeous perianth, only distinguishable by position and size, not different in colour and texture. All very small.

† Flowers in the centre of a hard leaf-like branch (cladode) with spinescent point; perianth of 3 smaller outer and 3 larger inner segments. Liliaceous type.

Ruscus aculeatus, L. Butcher's Broom (Fig. 94). Small

Fig. 94. Butcher's Broom, *Ruscus aculeatus*. Flowering branch; *a* scale, from the axil of which springs the cladode; *cld* cladode; *fl* flowers, p. 266.

stiff greyish-green bush with hard pointed leaf-like branches (*cladodes*) bearing the small greenish-white flowers, in the axils of minute membranous scales near the middle of the flattened surface above.

Flowers diœcious, with a persistent 6-partite perianth, stamens 6, the filaments forming a tube, with often only 3 anthers developed in the male flowers. Female flower with a 3-celled ovary and a simple style with entire stigma; staminal column barren. Fruit a red berry. Our only woody Monocotyledon.

†† Flowers not on cladodes; but small, pink, and sessile in the axils of the upper leaves; petals and sepals 3 each, scale-like, imbricated. Fruit small, black, drupe-like.

Empetrum nigrum, L. Crowberry. Glabrous, heath-like sub-shrub, prostrate like *Loiseleuria*, with small, crowded, evergreen, rolled leaves.

Flowers diœcious, minute, sessile in the axils of the upper leaves, pink or purplish. Chiefly anemophilous. Perianth of 3 outer and 3 inner, hypogynous, imbricated scale-like segments, and about 6 basal bracts. Male flowers with 3 exserted, free stamens. Female flower with a single superior ovary, on a fleshy hypogynous disc 3—9 chambered; style short; stigma with 6—9 radiating arms. Fruit black, globose, about the size of a pea, with one chamber and bony endocarp.

** Flowers with sepals different from petals —i.e. dichlamydeous; not sessile in upper leaf-axils, and not pink; tetramerous.

† Ovary inferior and the 4 purple-brown petals epigynous. Flowers in dichasial panicle-like cymes, with decussate branches. Fruit a scarlet berry. Laurel-like shrub.

Aucuba japonica, Thunb. Garden Laurel (Fig. 95). Evergreen shrub with large green leathery polished leaves, often variegated. Popularly termed Laurel, but has no relationship with the true *Laurus*. Floral formula of the ♂ flower $K_{(4)}\ C_4\ A_4$ with a fleshy disc; of the ♀ flower $K(4)\ C4\ G1$ with 1 ovule.

Fig. 95. *Aucuba japonica*. *A*, shoot bearing male flowers; *B*, a male flower magnified; *C*, an inflorescence of female flowers; *D*, a female flower magnified; *E*, ovary, and *F*, fruit in longitudinal section, p. 268 (E and P).

The flowers are in branched dichasial cymes, terminal and axillary, and claret-purple or greenish. Visited by pollen-eating flies. The ♂ flower has a calyx of 4 minute teeth, a corolla of 4 petals arranged cross-wise at the margin of a disc, ovate to lanceolate, valvate in bud; stamens 4, inserted alternately with the petals, with subulate filaments and separate anther-lobes. No rudiment of ovary.

The ♀ flower has an inferior ovary, sunk in the calyx-tube, which ends above in 4 small teeth; petals as before, stamens none. Ovary 1-chambered, crowned by an epigynous disc, and a short thick style with an oblique and slightly bifid peltate stigma. Pollen ellipsoid, drying to tetrahedra, with 3 furrows.

†† Ovary superior, the 4 whitish petals very minute. Flowers in axillary tufts, yellowish-green. Fruit a black drupe. Spinose shrub.

Rhamnus Catharticus, L. The Buckthorn. Often has polygamous flowers, though they are usually dicœcious, and will then come here: its alliances are with *Rhamnus Frangula*. It is rather like *Prunus spinosa* in habit. See p. 310.

The small, yellowish-green flowers are in axillary bunches (really cymose, but may be solitary) at the bases of the young shoots: they are fragrant, entomophilous, and dicœcious. Pedicels longer than the calyx. Floral formula K_4 C_4 A 4 G 4. Sepals spreading crosswise, secreting honey; lanceolate, as long as the calyx-tube; petals very minute or even obsolete, and the short stamens when present superposed on them. Ovary sunk in the cup of the calyx and ripening to a black drupe about the size of a pea. Most of the flowers on a plant have either no stamens or no ovary, or mere rudiments of one or the other; but occasionally some of the flowers have both stamens and pistil, and are polygamous. Pollen white, rounded elliptic to ovoid, about 31 × 25 μ.

[The Holly is physiologically sub-dicœcious, but the stamens in the ♀ flowers are so apparently perfect and large that they appear ☿: moreover truly ☿ flowers do occur sometimes. See p. 288.]

(b) The ♂ and ♀ flowers on the same plant—i.e. "monœcious."

[For (ii) see p. 272.]

(i) Perianth single, very small and inconspicuous—i.e. the flower is monochlamydeous.

(*a*) *Flowers minute and numerous, enclosed, and hidden, in pear-shaped or top-shaped hollow receptacles, formed of the swollen floral axis, the inner sides and base of which are lined by them. Small tree with lobed harsh leaves, and white latex.*

Ficus Carica, L. Fig (Fig. 96). Small tree, with short stem and thick spreading branches bearing large, harsh, lobed leaves, with milky juice.

Flowers monœcious, appearing with the leaves, minute, lining the interior of a hollow pear-shaped axillary receptacle perforated at the apex, which ripens to the fleshy "fig," and may attain a length of 5—8 cm. but is much smaller in the wild state, and greenish-yellow to violet-brown. Flowers pedicellate, of three kinds; hermaphrodite, with a 3—5-fid perianth and 3—5 stamens surrounding the ovary; male, of similar structure but wanting the ovary; and female, with a 5-partite perigone, a superior ovary with one ovule, lateral style and bifid stigma. Entomophilous (see p. 164). Fruit proper, achenes, immersed in the pulp of the receptacle.

[The fleshy receptacle (*Hypanthodium*) is comparable to a capitulum, the apex of the receptacle of which is pushed in, the sides growing up around it and meeting at the top, so that what was the outside bearing the flowers becomes introverted. There are allies of the Figs—e.g. *Dorstenia*—which show intermediate stages, in illustration of which Fig. 7 would serve. See also p. 164 for fertilisation.]

Fig. 96. Fig, *Ficus Carica*. 1, flowering shoot; 2, female, and 3, male flower enlarged; 4, the fig in section, reduced, p. 270 (Wo).

(β) *Flowers not enclosed in the floral axis, but in small clusters in the axils of ordinary leaves; each cluster with one terminal ♀ flower, surrounded by several ♂ flowers. Evergreen shrub with hard glossy entire leaves.*

Buxus sempervirens, L. Box (Fig. 97). Evergreen, glabrous shrub with small leathery leaves and angular shoots.

Floral formula ♂ P_4 A_4; the stamens opposite the perianth-segments, and a rudimentary ovary present; ♀ P_{4-12} $G\underline{(3)}$; the styles persistent on the valves of the globoid capsule; seeds black, 1—2 in each cell, flipped out by the compression of the hard endocarp. Monœcious, with exposed honey, entomophilous and occasionally anemophilous.

Flowers yellowish, in sessile axillary clusters, each consisting of a terminal, central ♀ flower, surrounded by about four to eight leaf-scales, some of which may represent a perianth, the others bracts; beneath this

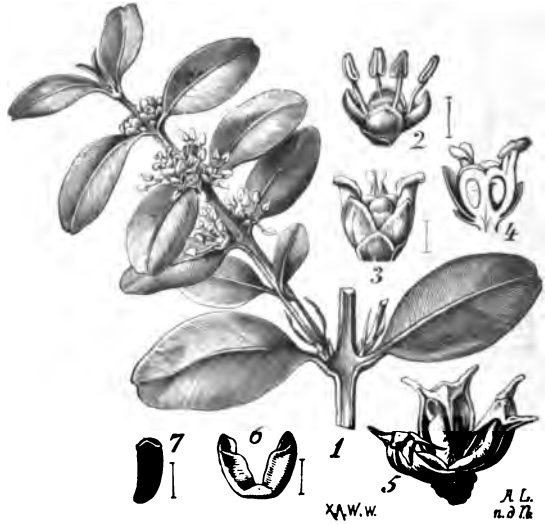


Fig. 97. Box, *Buxus sempervirens*. 1, flowering shoot; 2, a male, and 3, a female flower; 4, vertical section of latter; 5, ripe fruit opening; 6, carpellary walls; 7, seed. All but 1 enlarged, p. 271 (Wo).

are several ♂ flowers, each composed of four perianth-scales and four superposed stamens, and in the axil of one of the decussate leaves of the tuft. Pollen whitish, globoid, opaque, densely beset with minute warts, about 37 μ in diameter.

(ii) Perianth double, forming a calyx, and a corolla,—i.e. dichlamydeous; collected in dense spherical heads (capitula) sessile

at intervals or terminal on long pendent stalks Large trees with lobed leaves.

Platanus orientalis, L. Plane. Large tree, with

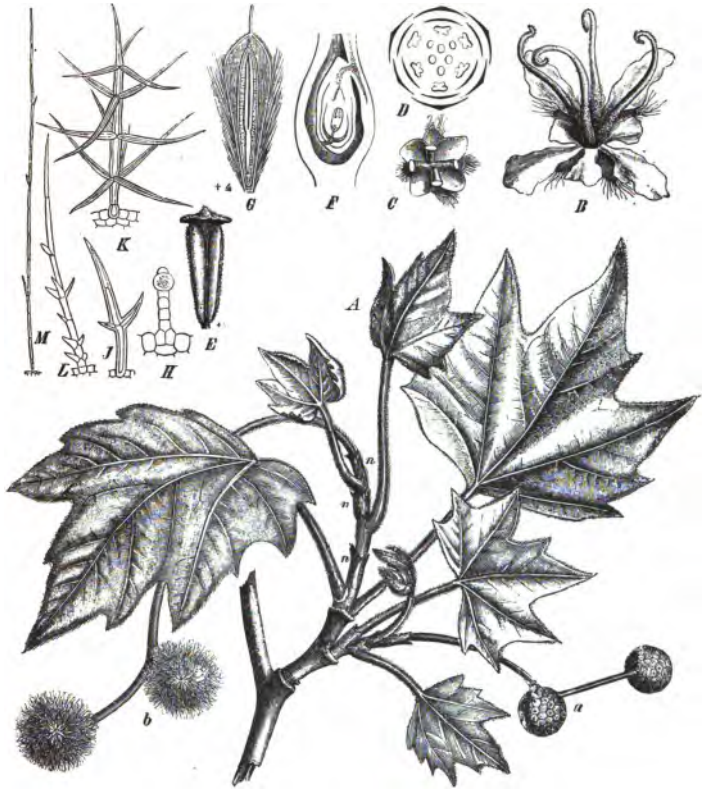


Fig. 98. *A*, shoot of *Platanus occidentalis*; *a*, male, and *b*, female flowers; *n*, stipules; *B*, female flower magnified; *C*, male flower with stamens removed; *D*, floral diagram, theoretical; *E*, ovary; *F*, ovary in section; *G*, fruit (caryopsis); *H*, glandular hair; *J* and *K*, ordinary hairs of leaf; *L* and *M*, hairs at base of fruit, p. 273 (E and P).

palmately lobed leaves and pseudo-palmate venation; buds buried in the swollen leaf-bases.

Flowers monœcious and anemophilous, proterogynous. Heads greenish, globoid, on the end and sides of a pendent, villous, cylindric flexible stalk 3—15 or more cm. long, developed from the tips of the dwarf shoots; the ♂ about 5—7, the ♀ about 10—13 mm. in diameter. Anthers yellow, pollen minute, ellipsoid, with 3 bands; stigmas purple.

Fruiting heads up to 3·5 cm. diameter, and looking like rough spheroidal buttons when young, warted owing to the projecting tips of the closely aggregated obcuneate nutlets. Floral formula $K_{3-4}\ C_{3-4}\ A_{3-4}$ (or $\underline{G}$ 3 or 4). Sepals triangular, hairy; petals spathulate, smooth; stamens opposite sepals; carpels tubular, tapering to a curved stigma; ovule 1. Caryopsis with a basal hair tuft.

[*P. occidentalis*, Button Wood, scarcely differs except in the lobing of the leaves (Fig. 98).

The inflorescence reminds one in some respects of the pendent interrupted ♂ catkins of the Beech, in so far as the flowers are there in a tassel on a slender dangling stalk; but, being dichlamydeous, we cannot regard them as true catkins. See p. 252.]

B. FLOWERS NOT DICLINOUS, BUT NORMALLY WITH BOTH STAMENS AND PISTIL—i.e. HERMAPHRODITE: MONOCLINOUS.

[For (2) see p. 282.]

(1) Flower with or without a perianth—i.e. monochlamydeous—but devoid of distinct calyx and corolla.

[For (b) see p. 275.]

(a) Perianth absent (achlamydeous). Flowers small, in dense axillary panicles, of decussate racemes; each flower consisting at most of a bottle-shaped ovary and 2 stamens.

Fraxinus excelsior, L. Ash (Fig. 99). Large tree, with black buds, opposite pinnate leaves, and grey bark; and polygamous, partly entomophilous, and partly anemophilous flowers.

Flowers proterogynous, appearing before the leaves, in crowded axillary compound racemes, or lax or dense, cymose; appearing purple-black, owing to the masses of deep purple-brown anthers and stigmas. The inflorescences emerge beneath the leaf-buds for the year. Each ramification with a small ligulate caducous bract. Male flowers achlamydeous, with 2 stamens, more or less connate below. Pollen mealy, rough, ellipsoid with 3 bands.

Female flower with a rudimentary perianth (calyx) enclosing a 2-chambered superior ovary, with a style dilated into two thick stigmas above. Hermaphrodite flowers naked, with an ovary and two stamens, also occur. Fruit one-chambered and one-seeded by abortion, pendent on a long stalk, flat, ligulate, prolonged anteriorly into a thin veined wing.

[The Ash is a member of the *Oleaceæ*, and comes near *Ligustrum* and *Syringa*, but being achlamydeous this is not evident until other species (e.g. *F. Ornus*) are examined which have a corolla. The flowers are frequently unisexual and even dicœcious, but all forms (polygamous) may occur on one tree.]

(b) Perianth present, of one series only, coloured or not, but never divisible into a calyx and corolla—i.e. monochlamydeous.

(i) Perianth consisting of 4 separate segments, all alike and petaloid, and each separately inserted on the floral axis below the hypogynous stamens and the apocarpous pistil (Thalamifloræ). [For (ii) see p. 278.]

Fig. 99. Ash, *Fraxinus excelsior*. 1, flowering dwarf shoots with hermaphrodite flowers; 2, female inflorescence; 3, 4 and 5, hermaphrodite flowers; 6, male flower; 7, ovary; 8 and 9, ovary in vertical and transverse section; 10, winter twig with fruits; 11, seed in section; 12, seed torn open; 13, seedling, p. 275 (Wi).

Clematis vitalba, L. Traveller's Joy, Old Man's Beard (Fig. 100). Lax shrub, climbing by means of the tendril-like stalks of the opposite pinnate leaves.

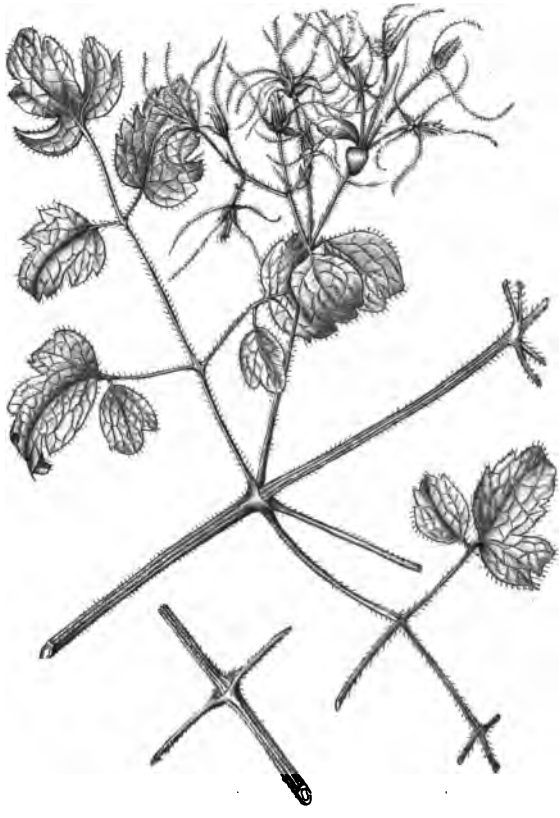


Fig. 100. Traveller's Joy, *Clematis vitalba*, p. 277 (Sch).

Flowers in lax, terminal, repeatedly trifurcate cymose panicles. Entomophilous, proterogynous, pollen-flowers. Perianth-segments (sepals) 4, greenish white, oblong,

villous on both surfaces, valvate in bud. Stamens numerous, pollen pale yellow, ellipsoid, punctate, with 3 longitudinal folds: 18 μ. Achenes plumed by the elongated plumose styles.

[The petal-like sepals are greenish white, spreading; stamens and carpels indefinite, the latter ripening to achenes, each with a long plumose style. Its proper place is near *Berberis*. See p. 285.]

(ii) Perianth not of separate segments, but gamophyllous.

[For (β) see p. 281.]

(*a*) *Perianth bell-shaped, olive-brown or purplish, with about 5 lobes and as many stamens inserted at its base, around the 2-celled 2-styled flat ovary. Fruit an oval flat winged samara.*

* Samara with seed nearly central, slightly notched above.

Ulmus montana, Sm. Wych Elm. Large tree, with spreading branches and broad, rough, more or less hairy leaves and proterogynous, anemophilous flowers, which rarely have germinable seed.

Flowers purplish, in dense axillary, rounded clusters (dwarf shoots) of dichasial cymes; investing bracts caducous; pedicels not longer than the perianths. Perianth funnel-shaped to bell-shaped, 5—6-toothed, purple, ciliate. Stamens about 5—6 and twice as long as the perianth. Anthers violet. Pollen white, irregularly roundish, polygonal, with sinuous ridges, 30—37 μ. Fruits thin and flattened, broadly ovate or sub-orbicular with tapering base, glabrous, veined, and remaining long green and leaf-like; notched at the apex, and carrying the seed near the centre.

** Samara with seed near the apex, deeply notched.

Ulmus campestris, Sm. Elm (Figs. 101, 102). The perianth may be 4- or 5- up to 8-lobed with as many stamens placed opposite the lobes. The flowers are frequently ♂ only, by abortion, and ripe seeds are rarely perfected.

Fig. 101. Elm, *Ulmus campestris*. 1, flowering shoot; 2, twig of the preceding year, with tuft of fruits and a dwarf shoot bearing foliage; 3, a flower; 4, ovary; 5, fruit; 6—8, seeds; 9, buds, p. 279 (Wi).

The dense clusters of flowers are each composed of a short axis bearing a few leaves, the lowermost of which are distichous and devoid of flowers, the upper spiral and each with a flower in its axil. The ovary is one-celled,

and has 2 stigmas. The 1-seeded samara hangs for a long time in spring like a round, green leaf. Tall and usually narrow tree, with the leaves and twigs less coarse and hairy than in *U. montana*. Flowers in small, hemispherical tufts, on pedicels 1—2 mm. long. Perianth rusty red, campanulate, margin white ciliate. Stamens about 5, with rusty anthers, and 2—3 times as long as the perianth. Flowers and pollen like that of *U. montana*. Globoid, rough, with curved striæ, and one large pore and germinable seed even rarer. Fruit more or less obovate 10—15 (up to 25) × 8—20 mm., very short-stalked, glabrous, whitish; the seed reddish and near the anterior notch.

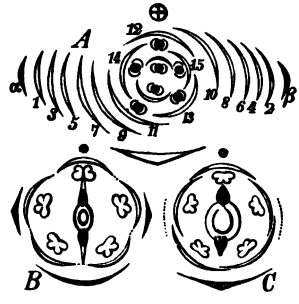


Fig. 102. Elm, *Ulmus campestris*. *A*, plan-diagram of a flowering tuft in bud; α, β bracts; 1—10, empty bud-scales (stipules); 11, 12, &c., the same with flowers in the axils. They pass from distichous to spiral phyllotaxy. *B*, diagram of flower; *C*, floral diagram of *Celtis*, p. 279 (Ei).

[Several varieties or sub-species of Elm are distinguished, of which the Cork Elm (*U. suberosa*, Ehr) is only *U. campestris* with strongly developed corky ridges on the branches.

U. effusa, Willd., resembles *U. campestris* in most respects, but has scaly bark and much pointed buds; thinner leaves on shorter petioles; longer pedicels and

looser pendent flower-tufts; the perianth more open and oblique; more numerous (6—8) stamens with violet anthers; and the seed more nearly central than in *U. campestris.*]

(β) *Perianth tubular, with 4 spreading lobes. Flowers in axillary clusters. Fruit berry-like.*

* Flowers in small racemose clusters of 3—4 in the axils of the glossy evergreen leaves; green and scentless; berry bluish-black.

Daphne Laureola, L. Spurge Laurel. Small shrub, with pliant branches, and lanceolate tough glossy leaves, in tufts. Flowers green and scentless, in racemose clusters of 3—4 in the axils of the ordinary leaves. Entomophilous, homogamous, secreting honey at the base of the tube.

** Flowers in clusters over the scars of fallen deciduous leaves; purple and sweet-scented; berry red.

Daphne Mezereum, L. Mezereon (Fig. 103). Bush, with erect withy branches, bearing purplish pink clusters of flowers before the deciduous leaves. Flowers in dense axillary clusters, forming interrupted spikes under the terminal bud or leaf-tuft; fragrant. Entomophilous, homogamous, honey flowers. Berry sub-globose, red.

Fig. 103. Mezereon, *Daphne Mezereum*. 1, flowering shoot; 2, vertical section of flower enlarged; 3, fruiting branch, p. 281 (Wo).

(2) Flowers with a double perianth, consisting of an outer calyx and an inner corolla, distinguished by differences in shape, texture, insertion and usually in colour also—i.e. dichlamydeous.

[For (b) see p. 333.]

(a) Corolla of separate petals each with its own insertion—polypetalous.

[For (ii) see p. 301.]

(i) Petals and stamens inserted on the floral axis, or on a ring of tissue (the disc), beneath the superior ovary—i.e. they are hypogynous.

(*a*) *Floral axis devoid of a disc, or at most there are traces of glands beneath the ovary.* [For (*β*) see p. 295.]

* Petals and sepals in whorls of 3, all alike in colour, golden yellow (petaloid); carpel single; stamens 6, anthers valvate.

† Flowers in simple racemes, terminating the dwarf shoots; berry oblong, orange-scarlet; leaves simple, some as spines.

Berberis vulgaris, Barberry (Figs. 104, 105). Spinose

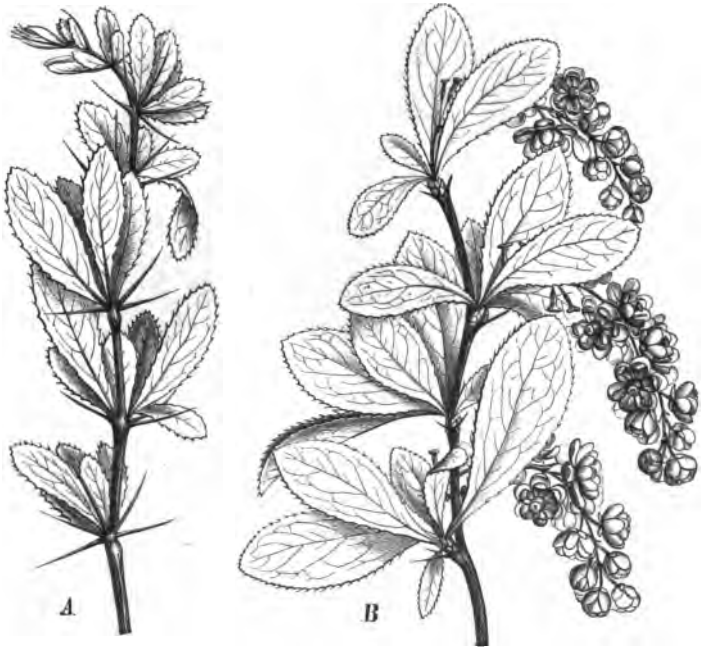


Fig. 104. Barberry, *Berberis vulgaris*. *A*, ordinary foliage shoot; *B*, flowering shoot, p. 283 (E and P).

shrub, with tufted leaves, and homogamous flowers with the honey partly exposed.

Racemes 4—6 cm. long, with about 15—20 or more flowers on short (6—12 mm.) pedicels. Flowers about 10 mm. in diameter. Floral formula $K\,3+3$, $C\,3+3$, $A\,3+3$, $\underline{G}\,1$, the inner 6 perianth-leaves are termed honey-leaves and not petals by some authors. All imbricate. The 6 free stamens are irritable and the anthers open by valves at the base. Ovary of one carpel, 1-chambered, with few ovules; stigma broad, sub-peltate, sessile. The two inner whorls of perianth-leaves (petals)

Fig. 105. Barberry, *Berberis vulgaris*. 1, flowering shoot; 2, flower in vertical section, enlarged; 3, a petal; 4 and 5, a stamen; 6, fruit, p. 283 (Wo).

have honey-glands at the base. Entomophilous. (See p. 56.) Flowers sub-globoid, almost bell-shaped, yellow, glands deeper orange in colour. Stigma green, odour curious. The outer row of perianth-leaves (sepals) are subtended by two or three minute bractlets.

†† Racemes in the axils of bud-scales; berry globose, blue-black; leaves pinnate, evergreen.

Berberis Aquifolium, Ph. Mahonia. Differs but little from the Barberry, except that the leaves are pinnate and evergreen spinescent-toothed and glossy, and the flowers more orange.

Racemes grouped three to six together, dense-flowered, and up to 10 cm. or so long: bracts about 6 mm. long. Pedicels 5—10 mm., their bracteoles 2—3 mm. long. Pollen pale yellow, punctate, irregular, rounded and large, about 34 μ, with crossing rills as if tetrads.

[*Clematis* also comes here, except that its perianth is single, whence it is dealt with on p. 277. It has the hypogynous arrangement and apocarpous pistil, the latter of several carpels, and the numbers throughout differ.]

** Sepals, petals and stamens not in threes, or multiples of three, but in multiples of four or five. Calyx and corolla obviously distinct. Ovary syncarpous.

† Flowers small, 3—4 mm. in diameter, pink, in dense slender erect spikes. Stamens 4—5; fruit a capsule; seeds comose. Branches slender and crowded with minute scale-like imbricated leaves.

Tamarix Gallica, L. Tamarisk. Leaves minute and scale-like, crowded and imbricate on the slender branches, reminding one of the Cypresses; but this resemblance, as also the still stronger resemblance of the catkins, capsules and comose seeds to Willows, is purely superficial. Floral formula $K_{4-5}\ C_{4-5}\ A_{4-5}\ \underline{G\ (3)}$.

Flowers in lateral, crowded, cylindroid spicate racemes, small, rosy, with 5 stamens and 10-lobed hypogynous

sheath, globoid in bud. Pollen whitish, and polymorphic: minute grains ovoid with 1 fold; larger, ellipsoid-fusiform truncate, with 3 longitudinal folds 18—30 μ. Capsule 3-angled, pyramidal.

†† Flowers not on spikes; and the leaves not small and crowded or imbricated.

⊙ *Flowers all regular, actinomorphic.*

▱ *Flowers in cymes with a long bract adnate to peduncle; stamens numerous, in clusters. Flowers at least* 8—10 *mm. diameter, greenish; not in spikes, and fruits not capsular; a carcerulus.*

Tilia europœa, L. Lime (Figs. 106, 107). Tree with oblique cordate leaves, and protandrous flowers rich in honey.

The floral formula of *Tilia* is $K_5\ C_5\ A_\infty\ G\underline{(5)}$. Cyme pendent, many-flowered, about as long as the lamina, which hangs over it as if roofing it in; repeatedly forked, and nearly umbellate, on a stiff peduncle springing from the middle of a ligulate, veined, yellowish-green, glabrous, membranous and petiolate, axillary bract about as long as the leaf and its petiole together. Flower rather small, sweet-scented and secreting much honey. Petals yellowish-white; stamens about 30, longer than the petals. Pollen yellowish-white, tetrahedral to ellipsoid or ovoid, densely papillate, opaque, with 3 pores on the angles; about 30—40 μ. Style single, as long as the hairy ovary. Fruit small, sub-globose, slightly angular, reddish-brown.

[The variety *grandifolia* has larger, hairy leaves; cymes with fewer (2—3) and larger flowers, shorter than the lamina and on a bract shorter than the whole leaf, and flowering somewhat earlier. Fruit larger, more angular, and harder.]

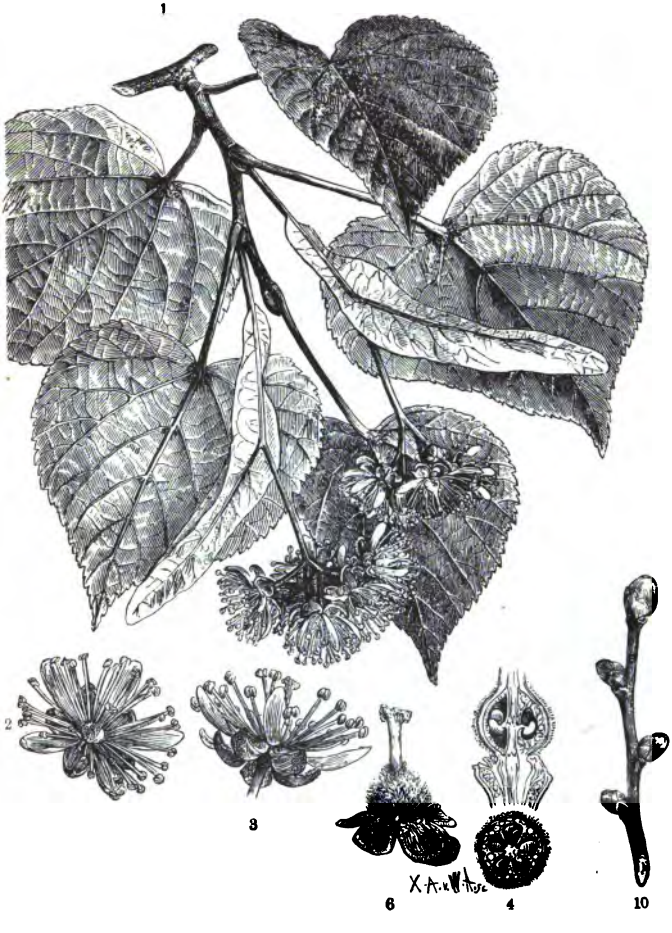


Fig. 106. Lime, *Tilia europæa*, var. *parvifolia*, L. 1, flowering shoot; 2 and 3, flowers from above and from the side; 4, ovary in transverse and longitudinal section; 6, ovary, style and stigma; 10, buds, p. 286 (Wi).

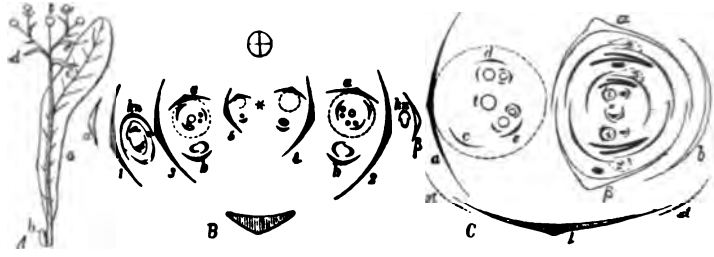


Fig. 107. Lime, *Tilia europæa*. *A*, inflorescence fused with its bract *a*, at the base of which is a bud *b*; *B*, plan of a flowering shoot; *C*, plan of the inflorescence and bud of *A*, corresponding to the group subtended by the leaf 3 in *B*, p. 286 (Ei).

▱▱ *Inflorescence devoid of adherent bract; stamens equal in number to the sepals and petals. Flowers small.*

§ *Corolla white, almost gamopetalous; sepals, petals and stamens* 4, *rarely* 5. *Flowers in short axillary cymose tufts, sub-dicecious. Shrub with spinescent leaves and no tendrils.*

Ilex Aquifolium, L. Holly (Figs. 108, 109). Shrub or small tree, with hard, polished, spinescent-toothed or, in old plants, more or less entire leaves.

Flowers small, in short, axillary cymose tufts; sub-dicœcious, or some ♀, with exposed honey, and entomophilous. Sepals 4, minute, yellowish-green, imbricate in bud. Corolla composed of 4 white petals, placed crosswise, imbricate, very slightly connate at the base. Stamens alternate, inserted with the corolla. Anthers yellow. Pollen ellipsoid, bluntly papillate, with 3 rough bands. Disc none.

Ovary superior, 4-chambered, one ovule in each chamber. Fruit globoid, as large as a pea, red, flesh thin. Floral

formula $K_4 C_4 A_4 G\,(\underline{4})$. The corolla is so deeply divided that we must regard its minute obovate segments as separate petals. The stamens may be just adherent to the base

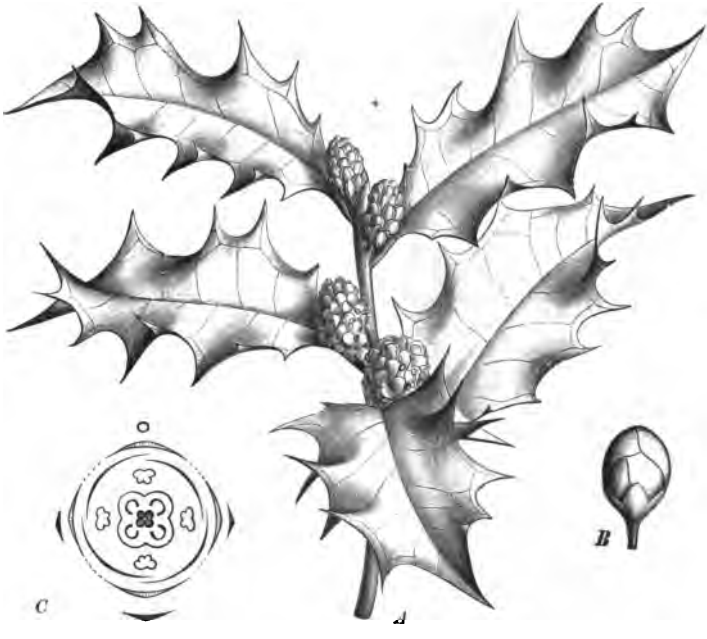


Fig. 108. *Ilex Aquifolium*, Holly. *A*, branch with inflorescences, all the flowers of which are ♂; *B*, flower-bud; *C*, floral diagram, p. 288 (E and P).

of the corolla. While the Holly flower is structurally hermaphrodite, it is physiologically dicœcious in most cases, the stamens of the ♀ flower, large as they are, carrying no fertile pollen; sometimes, however, they are fertile and the flower is ☿. See p. 269.

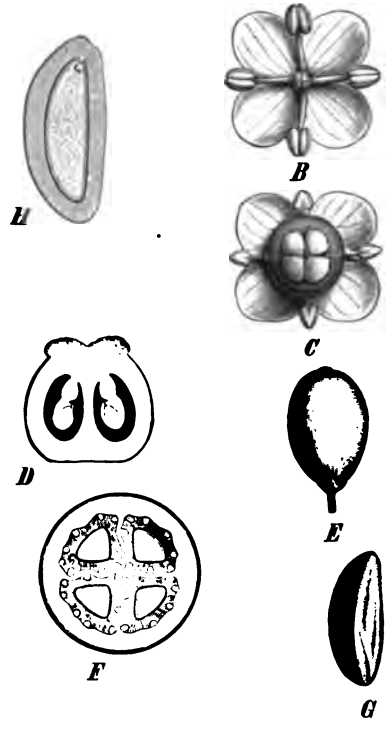


Fig. 109. Holly. *B*, a ♂ flower; *C*, a ♀ flower; *D*, longitudinal section of ovary, showing the pendent ovules; *E*, fruit; *F*, the same in transverse section; *G*, seed; *H*, the same in longitudinal section, p. 288 (E and P).

§§ *Flowers greenish; sepals, petals and stamens* 5 *each, the latter* opposite *the petals, and with minute glands between their bases, flowers in complex branched cymes. Tendril climbers.*

‡ *Petals united above, and pushed off as a cap by the stamens.*

Vitis vinifera, L. Vine (Figs. 110, 111). Climber, with leaf-opposed branch-tendrils.

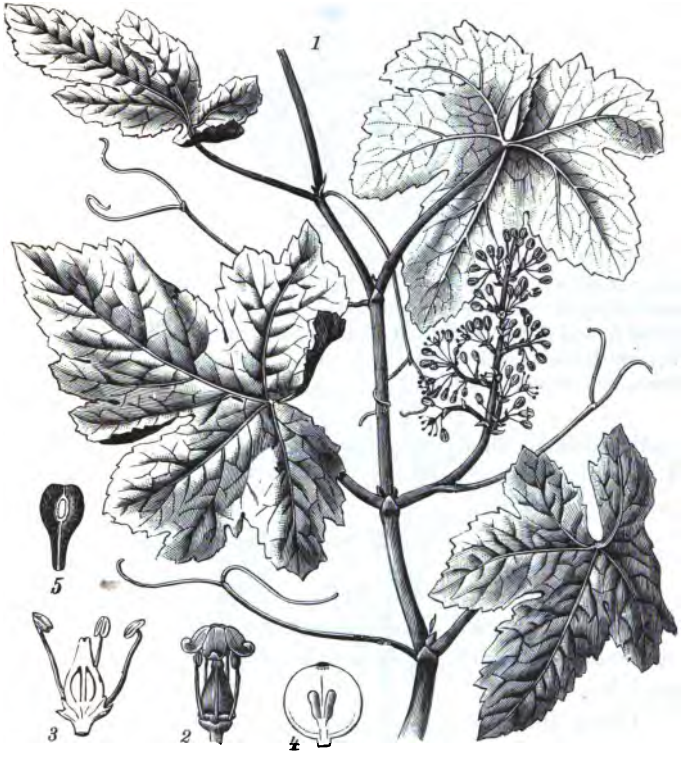


Fig. 110. Vine, *Vitis vinifera*. 1, flowering shoot; 2, flower casting the petals as a cap; 3, vertical section of flower; 4, ditto of fruit; 5, seed, p. 291 (Sc).

Flowers small, yellowish-green, in dense panicles. Calyx 5-toothed, petals and stamens 5 each, the former coherent above and pushed off in the form of a cap by the latter.

Style short; stigma simple, lobed. **Entomophilous.** Pollen greenish-yellow, large, ellipsoid-truncate, with 3 longi-

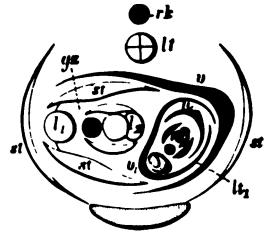


Fig. 111. Vine. Plan-diagram of shoot-system; *rk*, tendril, ending the axis; *lt*, shoot; *st*, stipules of the leaf on *lt*, and shown below them; r, bract from the axil of which spring two shoots, viz. *gz*, which begins with a leaf l_1, and its two stipules *st*, and of which l_2 is the second leaf, &c., and lt_1, which begins with a bract v_1 from the axil of which similar shoots arise, and so on, p. 291 (Ei).

tudinal folds, finely alveolate, about 53 μ long. Berry 1-chambered, 2—4-seeded.

‡‡ *Petals expanded and not pushed off.*

Ampelopsis hederacea, Mchx. Virginian Creeper (Fig. 112). Climber, with leaf-opposed tendrils, palmate leaves, and small, protandrous, honey-bearing flowers in complex panicles.

Calyx almost entire or obsolete; petals and stamens 5, the former spreading, and not coherent into a cap. Entomophilous. Pollen sulphur-yellow, ellipsoid-truncate, with 3 longitudinal folds, finely alveolate, about 53 μ long.

⊙⊙ *Flowers large, irregular, more or less obliquely zygomorphic; stamens about* 7. *Inflorescence large, pyramidal, panicle-like but with cymose ends to the branches* (*thyrsus*).

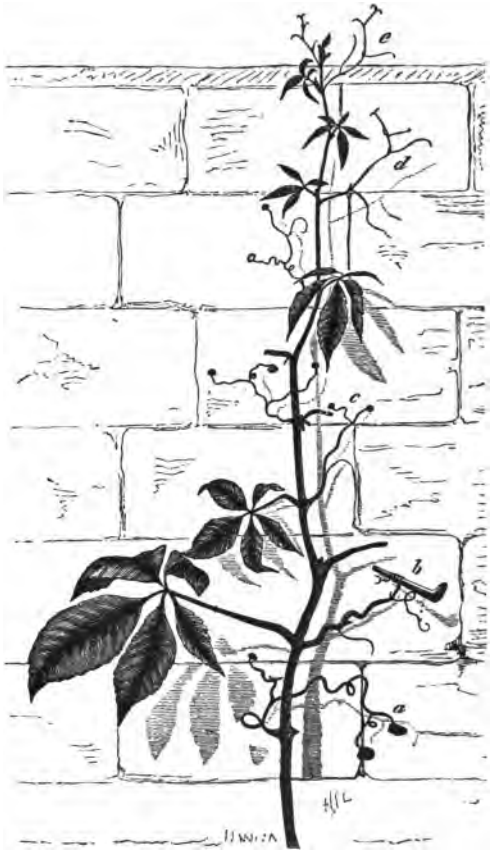


Fig. 112. Shoot of *Ampelopsis*, Virginian Creeper, climbing by means of branch-tendrils, some of which twine round nails, &c. (*b*), others fasten their tips to the bricks by means of sucker-like dilations (*a* and *c*); *d* and *e* young tendrils, p. 292 (Sa).

Æsculus Hippocastanum, Horse-chestnut (Fig. 113). Tree, with large digitate leaves.

Inflorescence a racemoid panicle with cymose branches. Upper flowers ♂ by abortion. Floral formula $K_{(5)}\,C_{5\,(or\,4)}\,A8—5\,\underline{G(3)}$, disc extrastaminal. Flowers entomophilous, proterogynous, dichogamous and honey-bearing; in a large erect pyramidal mixed panicle (*thyrsus*). Calyx greenish; petals crisped and undulate, white with yellow basal flecks,

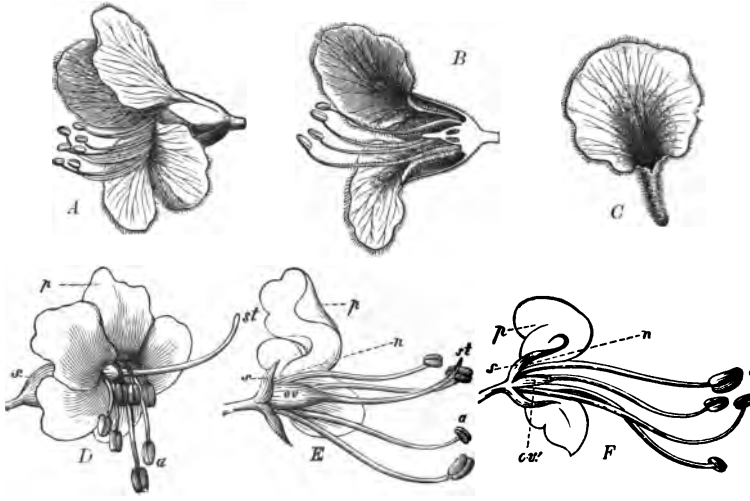


Fig. 113. Horse-chestnut, *Æsculus Hippocastanum*. *A*, flower from the side; *B*, the same in longitudinal section; *C*, a petal of same. *D*, a ♂ flower in the ♀ stage, the stigma in position but the anthers as yet immature; *E*, the same in the ♂ stage, in section, the mature anthers now raised; *F*, a ♂ flower in section, p. 293 (E and P).

which turn rosy or purplish; stamens long and sweeping forwards, then erect. Pollen brick-red, elongated-oblong, smooth, 35—40 × 20 μ with about 3 longitudinal furrows, striated. Ovary and style glabrous. Fruit large, subglobose, with coarse prickles, splitting and exposing the large polished brown seed.

(β) *Disc conspicuous as a fleshy hypogynous ring, on which the stamens are inserted. Flowers in racemes, corymbs or panicles.*

* Ovary of two winged and flattened carpels, style one, stigmas two: sepals and petals 5 each, stamens 8. [For (**) see p. 299.]

† Flowers in pendent racemes; juice not milky.

Acer pseudoplatanus, L. Sycamore (Fig. 114). Tree, with opposite palmatifid leaves.

Floral formula $K_5\ C_5\ A\ 4+4\ \underline{G\,(2)}$. Flowers protandrous, with exposed honey. Flowers in pendent stalked racemes of umbellate cymes of about 3 each; opening after the inflorescence is complete, each on a rather long pedicel. Each terminal or central flower in the cyme usually hermaphrodite, the lateral male, with longer stamens and abortive pistils. Sepals and petals nearly alike, greenish-yellow. Stamens hairy; ovary tomentose. Pollen ellipsoid-fusiform, with 3 longitudinal bands and numerous striæ. Fruit pendent, glabrous, the two long green wings directed forwards and often nearly parallel to the fruit-axis.

†† Flowers not in pendent racemes but in corymb-like panicles of cymes; sap milky.

⊙ *Wings of fruits divaricating at angles of* 50—60° *with the axis.*

Acer platanoides, L. Norway Maple (Fig. 115). Tree like the last, but the lobes of the leaves more drawn out and angular.

Flowers in erect panicles of cymes, opening early, before the foliage expands, yellowish-green. Most of the earliest flowers are ♀, the later ♂ by abortion. Honey exposed. Stamens of the male flowers as long as the petals. Pollen elongated, pale yellow, about $50 \times 25\ \mu$, with 3 longitudinal

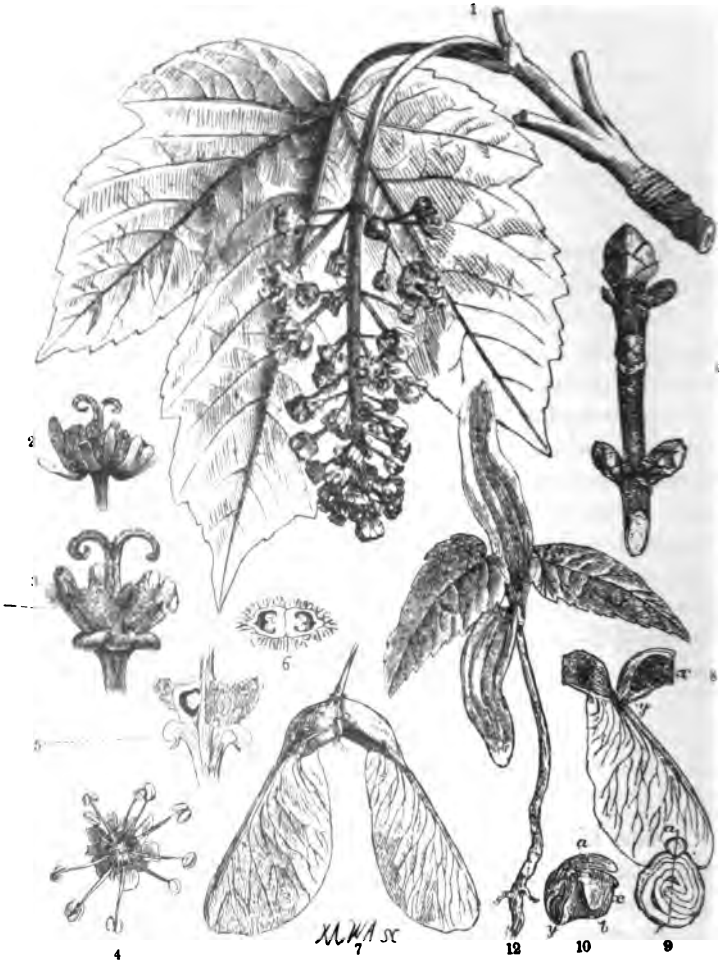


Fig. 114. Sycamore, *Acer pseudoplatanus*. 1, flowering shoot; 2, hermaphrodite flower; 3, the same after removal of the sepals and petals; 4, male flower seen from above; 5, ovary, with the left cell opened; 6, transverse section of ovary; 7, fruit; 8, the same opened and exposing the seed *x*, *y*; 9, seed in section across *a*, *b* in 10; 10, embryo; 11, buds; 12, seedling, p. 295 (Wi).

Fig. 115. Norway Maple, *Acer platanoides*. 1, flowering shoot; 2, hermaphrodite flower, after removal of calyx and corolla; 3, male flower, similarly treated; 4, ovary; 5, fruit; 6, opened fruit; 7, seed; 8, the same in section; 9, leaf; 10, buds, p. 295 (Wi).

furrows and numerous striæ. Ovary glabrous. Fruit pendent on long stalks, large, glabrous, with widely divergent, broad, half-ovate somewhat reflexed wings, standing out at angles of about 50—60° to the long axis of the fruit.

⊙⊙ *Wings of fruits extended horizontally at right-angles to the long axis.*

Acer campestre, L. Maple (Fig. 116). Much smaller tree than the preceding, or bush.

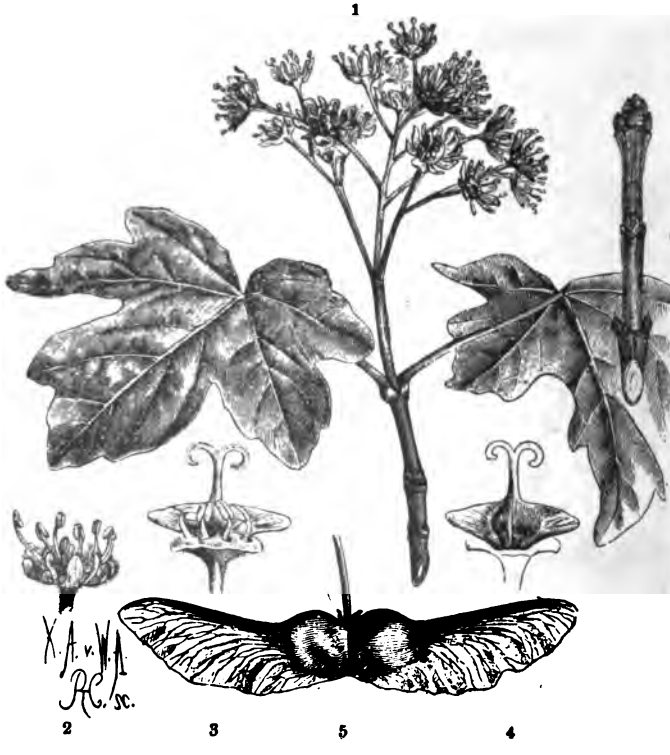


Fig. 116. Maple, *Acer campestre*. 1, flowering shoot; 2, male flower; 3, ovary and stamens on the glandular disc; 4, ovary; 5, fruit; 6, buds, p. 298 (Wi).

Flowers in erect panicles of cymes, at length more or less pendent, opening with or soon after the leaves, pale green, with hairy pedicels and perianths; the lateral male, others mixed in various degrees. Hermaphrodite flowers with glabrous ovaries. Honey exposed, entomophilous. Fruit glabrous or velvety with large, smooth, green, horizontally spreading wings. Pollen sulphur-yellow, oblong-truncate, with 3 longitudinal striated ridges, about 54 μ long.

** Ovary of 3—5 carpels. Fruit not a double samara.

† Ovary of 5 compressed carpels, separating as they ripen; styles 5, united; stamens 10.

Ailanthus glandulosa, Desf. Tree of Heaven (Fig. 117). A tree with large pinnate leaves, allied to the Sumach and the Maples, &c.; with small flowers crowded in terminal panicles, and polygamous.

Calyx of 5 half-ovate small segments, united below. Petals 5, much larger, ovate or oblong-lanceolate, with inflexed margins, hairy at the base, valvate in bud, hypogynous and free. Stamens 10, with long subulate filaments, hairy below, and inserted beneath a hypogynous 10-lobed fleshy disc which surrounds the base of the ovary. In some flowers the stamens are reduced in number or are absent, so that polygamy results. Anthers ovate or ovate-lanceolate.

Ovary of 5 carpels, syncarpous by their inner margins, flattened laterally, obovate to boat-shaped, each containing one ovule. In the ♂ flowers the carpels are rudimentary or even obsolete. Styles 5, united, with as many oblong reflexed stigmas. As the fruit ripens, the carpels separate, and each forms a thin, linear-lanceolate, compressed, veined

and winged samara twisted at the top; with one median seed.

Fig. 117. *Ailanthus glandulosa*, Tree of Heaven. *A*, inflorescence; *B*, a ♂ flower; *C*, a ♀ flower; *D*, vertical section of ovary, disc and base of stamens; *E*, fruit with three ripe carpels, one in section through the seed, p. 299 (E and P).

†† Ovary of 3 carpels, syncarpous, one-chambered; styles 3; stamens 5.

Rhus typhina, L. Sumach. Small tree somewhat allied to the Maples and Horse-chestnut, with thick red-hairy shoots, and large pinnate leaves: containing a sharp latex.

Flowers polygamous, hypogynous, small, greenish-yellow, crowded in large terminal and axillary pyramidal panicles, which in fruit become densely felted with dark purple tomentum. Honey exposed, entomophilous.

Calyx fused beneath to a broad fleshy hypogynous disc, 5-partite, persistent, segments imbricate in bud. Petals 5, small, but longer than sepals; inserted outside the disc; imbricate. Stamens 5, inserted beneath the disc; filaments subulate, anthers ovoid. Almost rudimentary in some flowers and barren, rendering the flowers ♀. Ovary ovoid, single, free, 1-chambered with one ovule, and 3 styles ending in blunt stigmas. Fruit small, like a dry drupe. Pollen large, ellipsoid, with 3 folds and striate.

(ii) Flowers not hypogynous, the stamens and petals being inserted on the calyx, or on a disc lining the calyx-tube (*perigynous*), or carried up on the throat of the calyx-tube to a level above the ovary (*epigynous*).

(*a*) *Flowers zygomorphic, papilionaceous; petals* 5, *the posterior the larger* (*standard*) *and folded in bud over the two laterals* (*alæ*) *which in their turn cover the small anterior boat-shaped carina: stamens* 10, *united all, or* 9 *only, into a tube; carpel* 1, *ripening into a legume* (*Leguminosæ*). [For (β) see p. 306.]

* The posterior stamen free, the other nine united; calyx campanulate, slightly 3-toothed; flowers white, in pendent racemes.

Robinia pseudacacia, L. False Acacia (Figs. 118, 119). Tree, with pinnate leaves and pulvinar spines; bearing

Fig. 118. *Robinia pseudacacia*, False Acacia. ♂, stipules, p. 301 (Sw).

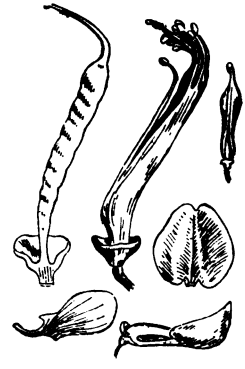


Fig. 119. Floral parts of *Robinia pseudacacia*. To the left above, the young legume and the calyx; to the right of this, the same with the stamens in position; to the right the keel seen from above; to the right below, the same from the side; next this the standard and one of the wings, p. 301 (Sw).

pendent racemes of white, fragrant, protandrous flowers, rich in honey and pollinated by bees.

Flowers white, scented, numerous, in long, pendulous, loose, axillary racemes. Calyx shortly and broadly toothed, the upper lobe slightly so, making it nearly 2-lipped; standard large and erect, with reflexed edges, yellowish at base; wings oblong, curved; keel curved, obtuse. Stamens 9 united, 1 free, almost equal. Pollen grey-white, smooth, ellipsoid, with 3 longitudinal folds, about 37 μ long. Ovary stalked, ovules numerous. Style sharply bent upwards at right-angles to the ovary: stigma capitate, crowned with hairs. Pods broad, flat, linear, 6—8 cm. long, glabrous, pendent, compressed and margined above, with about 4—7 seeds.

** Stamens all united: flowers yellow.

† Calyx deeply divided into 2 lips, and coloured yellow; flowers solitary or in pairs. Legume brown velvety.

⊙ *Flowers about* 15 *mm. long. Wings longer than the keel.*

Ulex europæus, L. Furze, Gorse (Fig. 120). Spiny shrub, with large yellow protandrous flowers, devoid of honey and pollinated by bees.

Flowers singly or in pairs in the axils of the uppermost leaves (spines) and so grouped into spike-like masses. Large, golden-yellow. Calyx hairy, divided to the base into two unequal lips. Alæ wrinkled at upper posterior margin. Stamens all united. Pollen deep yellow, rough, ellipsoid fusiform, with 3 longitudinal grooves. Style inrolled. Pod short, hardly longer than the calyx, hairy.

⊙⊙ *Flowers about* 7—8 *mm. long. Wings not longer than the keel.*

Ulex nanus, L. Dwarf Furze. Flowers like the

Fig. 120. *Ulex europæus*, Gorse, p. 303 (E and P).

last, but of a deeper golden-yellow; calyx glabrous or glabrescent, and bracts minute. In other respects similar to the foregoing.

†† Calyx green, not deeply bi-labiate; legume not brown-hairy.

⊙ *Calyx short campanulate; flowers large in long pendent racemes; legume strangled.*

Cytisus Laburnum, L. Laburnum. Tree with silky buds and trifoliolate leaves. Flowers protandrous, devoid

of exposed honey, pollinated by bees. Flowers in long, loose pendent racemes, numerous, large, golden-yellow, on distinct pedicels. Calyx 2-lipped; style ascending. Corolla yellow, the standard veined with dark lines. Stamens monadelphous. Pollen citron-yellow punctate, ellipsoid truncate, with 3 longitudinal folds; about 32 μ long. Pod long (up to 5·5 cm.), linear, compressed, silky-hairy, grey.

⊙⊙ *Calyx slightly cut into 2 lips.*

□ *Upper lip of calyx deeply 2-toothed; lower shortly 3-toothed; flowers 10 mm. long, in small leafy racemes.*

Genista anglica, L. Petty Whin. Small spinose bush, with flowers pollinated by bees, as in *Ulex*.

Flowers rather small, golden-yellow, in short, terminal, simple bracteate racemes. Calyx deeply 3-partite into 2 upper teeth and one broader 3-toothed lower lip. Stamens monadelphous, pollen ellipsoid-rounded, alveolate, with 3 folds. Style ascending. Pods broad, rhomboidal, and glabrous.

□□ *Both short lips of the calyx minutely toothed; flowers solitary or geminate, 20 mm. long.*

Sarothamnus Scoparius. Broom (Fig. 121). Twiggy bush, with large yellow homogamous flowers, devoid of honey, pollinated by bees.

Flowers lateral, singly or in pairs, on pedicels about as long as the calyx, large, golden-yellow, forming long bracteate racemes at the ends of the long shoots. Calyx 2-lipped. Stamens 10, monadelphous, 5 long and 5 short. Style very long and inrolled like a watchspring. Pods linear, up to 4 cm. long, compressed, black, and pubescent, especially at the margins.

Fig. 121. Broom, *Sarothamnus Scoparius*. 1, flowering shoot; 2, flower, p. 305 (Wo).

(β) *Flowers not zygomorphic, but regular, actinomorphic.*

[For (**)! see p. 320.]

* Flowers perigynous to sub-epigynous; the stamens and petals inserted on the throat of the calyx-tube: if the calyx-tube is long, and carries the insertions high, so as to appear nearly epigynous, the carpels are free and do not fuse with it.

† Flowers small, greenish and inconspicuous; not Rosaceous. Sepals, petals and stamens equal in number; ovary syncarpous. [For (††) see p. 309.]

⊙ *Sepals, petals and stamens 5 each: the petals very minute, on the inner margins of the cup-like calyx-tube, each with a small stamen opposite its base.*

Rhamnus Frangula, L. Alder Buckthorn (Fig. 122). Small tree.

Flowers hermaphrodite, whitish, in axillary cymose tufts, or paired, or single. Protandrous, with exposed honey. Stamens and petals 5 each. Pollen small, about 30 × 20 μ, white, smooth, rounded tetrahedral to ellipsoid with

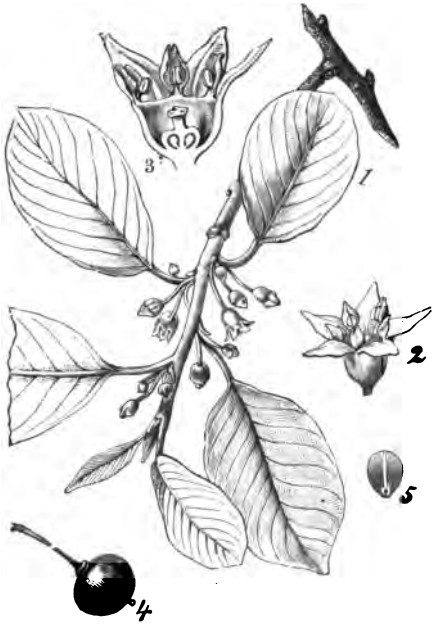


Fig. 122. Alder Buckthorn, *Rhamnus Frangula.* 1, flowering shoot; 2, flower; 3, the same in vertical section; 4, fruit; 5, seed. 2 and 3, enlarged, p. 307 (Wo).

3 folds. Style simple, stigma undivided. Fruit globose, about the size of a pea, passing through red to black.

[*Rhamnus Catharticus* also comes here, but the flowers are unisexual, and are therefore treated on p. 269.]

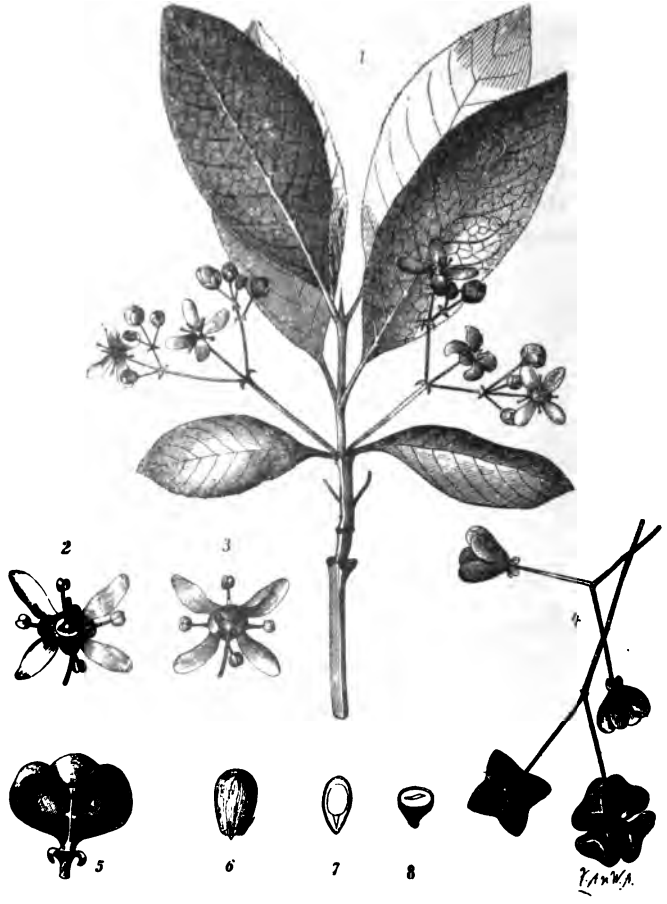


Fig. 123. Spindle Tree, *Euonymus europæus*. 1, flowering shoot; 2, 3, flowers from above and below; 4, fruit; 5, the same in section; 6—8, seed whole and in section, p. 309 (Wi).

⊙⊙ *Sepals, petals and stamens 4 each; the latter alternate, and inserted at the margin of a fleshy disc. Inflorescence an axillary dichasium.*

Euonymus europœus, L. Spindle Tree (Figs. 123, 124). Shrub, with opposite leaves and quadrangular twigs. Flowers small, greenish, protandrous, with exposed honey.

Floral formula $K_4 C_4 A_4 G_{(4)}$, but sometimes polygamous. Flowers with 4 calyx-teeth, petals and sepals. Petals linear, greenish-white, cruciate, as are also the long alternating stamens. Pollen whitish-yellow, ellipsoid or subgloboid, much warted and alveolate, up to 40—50 × 25 μ, with 3 folds. Capsule 4-angled, 4-valved with about 4 white seeds.

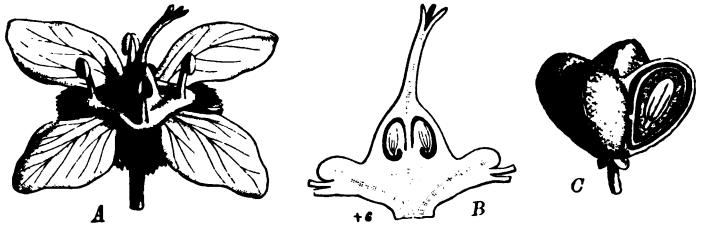


Fig. 124. Spindle Tree. *A*, flower; *B*, vertical section through the ovary, disc, and base of the stamens; *C*, fruit, with one carpel and seed in section (E and P).

†† Flowers Rosaceous, the stamens about twenty; sepals and petals 5 each, the latter relatively large, white, or pink and conspicuous. Ovary not syncarpous.

⊙ *Pistil of one carpel only—i.e. monocarpous—ripening to a single drupe. Calyx-tube cup-shaped; sepals deciduous.* [For (⊙⊙) see p. 315.]

▱ *Petals white. Drupe fleshy and indehiscent; stone hard, smooth or pitted but not wrinkled. Pollen large, ellipsoid,* [For (▱▱) see p. 313.]

with 3 *folds and longitudinally striate* (*Prunus*).

§ *Flowers axillary, single or in pairs, or clustered.*

‡ *Flowers on short pedicels, solitary or in small tufts; white, about* 10—15 *mm. in diameter. Drupe with waxy bloom. Leaves convolute.*

÷ *Spinose shrub, flowering before the leaves appear.*

Prunus spinosa, L. Blackthorn (Fig. 125). Thorny shrub, the white flowers proterogynous and offering pollen and honey.

Flowers single, on short stalks from the axils of the leaves, on the dwarf shoots so close together that the flowers appear tufted; opening before or with the foliage. Pedicel and calyx glabrous, green; petals snow-white, anthers yellow. Fruit shortly stalked, erect, sub-globose, purple-black pruinose, with green and very astringent flesh.

÷÷ *Thorns few or none; flowers larger, and appearing after the leaves.*

8 *Pedicels short and downy.*

Prunus spinosa, var. or sub-sp. *insititia*, has fewer or no thorns, the flowers chiefly in pairs, on hairy pedicels, larger, white, and opening later, with the foliage. Fruit oblong, with sweeter flesh.

8 8 *Pedicels longer and glabrous.*

Prunus spinosa, var. or sub-sp. *domestica*, has no thorns, glabrous shoots, greenish-white and smaller flowers, and fruit pendent on longer stalks.

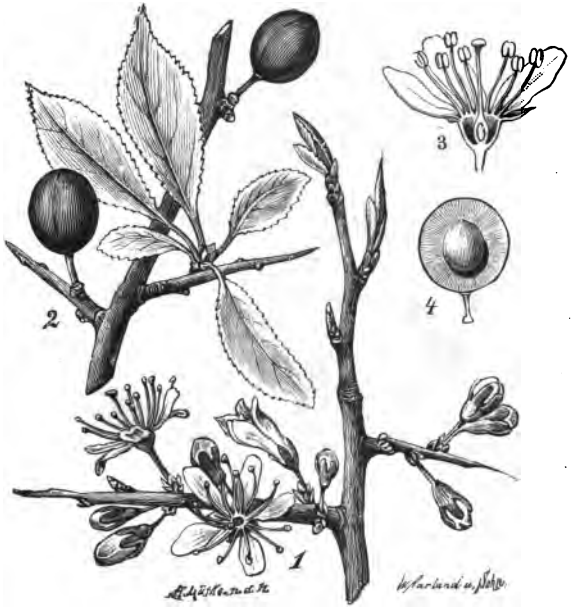


Fig. 125. Blackthorn, *Prunus spinosa*. 1, flowering shoot; 2, fruiting branch; 3, flower in vertical section, enlarged; 4, fruit in section, p. 310 (Wo).

‡‡ *Flowers on long stalks, in umbellate clusters, about* 20—30 *mm.; leaves conduplicate; fruits not pruinose.*

÷ *Calyx-tube not constricted above; sepals serrate, petals firm; leaves not drooping.*

Prunus Cerasus, L. Cherry (Fig. 126). Tree, with glistening periderm.

Flowers large, on long pedicels, in umbellate tufts surrounded at the base with small green leaves, white or tinged with pink. Proterogynous, offering pollen and honey. Fruit red to black, sweet but astringent and acid.

Fig. 126. Cherry, *Prunus Cerasus*. 1, flowering shoot; 2, leaf; 3, bud-scales; 4, 5, flower in vertical section; 6, fruit, p. 311 (Wo).

÷÷ *Calyx-tube constricted above; sepals entire, petals flaccid; leaves long-petiolate and drooping.*

Prunus Cerasus, var. or sub-sp. *Avium*, the Gean, has

equally large or even larger flowers, up to 35 mm. diameter, in similar tufts with coloured membranous bracts at the base, and bitter-sweet black-red fruits 12—15 mm. in diameter. Pollen sulphur-yellow, ellipsoid-rounded, 52 μ long, with longitudinal folds and striæ. Flowers homogamous, offering pollen and honey.

§§ *Flowers in axillary racemes; leaves conduplicate.*

♯ *Racemes lax and pendent; leaves deciduous, with glandular petioles.*

Prunus Padus, L. Bird Cherry (Fig. 127). Small tree, with proterogynous flowers offering pollen and honey. Flowers opening after the foliage, in pendent racemes, small, white, sweet-scented. Fruit as large as a pea, black, bitter-sweet.

♯♯ *Racemes stiff and erect. Leaves evergreen, the petioles eglandular.*

÷ *Leaves with glands flanking the midrib below.*

Prunus Laurocerasus, L. Cherry Laurel. Flowers small, white, fragrant, in erect slender racemes; offering pollen and honey. Fruit sub-globose, black.

÷÷ *Leaves devoid of glands.*

Prunus Lusitanica, L., Portugal Laurel, is very similar, but has harder and thinner, darker foliage devoid of glands, and the twigs and petioles purplish.

□□ *Petals pink. Drupe tough and leathery, at length dehiscent; stone relatively soft, much wrinkled.*

Amygdalus communis, L. Almond. Small tree, with

Fig. 127. Bird Cherry, *Prunus Padus*. 1, flowering shoot; 2, fruiting raceme; 3, flower in vertical section, the petals removed, p. 313 (Wi).

lanceolate leaves, and purplish-pink flowers appearing early, before the foliage, proterogynous, with half-exposed honey.

Flowers large, single or in pairs, on short pedicels, from axillary buds. Calyx-tube purplish, cup-shaped; sepals green, dashed with red, glabrous. Petals pink. Fruit dry, green, villous, otherwise plum-like but dehiscent.

⊙⊙ *Pistil of many separate carpels—i.e. apocarpous. Sepals persistent.*

▱ *Calyx of widely spreading sepals, fused below, buds not forming a tube. Pollen ellipsoid, punctate. Fruit a head of small drupels, on a conoid receptacle.* (Rubus.) [For (▱▱) see p. 317.]

§ *Fruitlets adhering to the receptacle. Shoots usually scrambling, prostrate or more or less arching, and armed with hooked claw-like prickles.*

♯ *Stems slender, terete, and glaucous. Fruits bluish with a waxy bloom. Sepals narrow and closing over the fruits.*

Rubus Cæsius, L. Dewberry. Bush, with slender shoots. Flowers in short few-flowered cymes.

Pollen grey-white, ellipsoid, punctate, with 3 folds, about 38 μ long. Homogamous, with abundance of honey. Fruit black, pruinose, acid, adherent to the receptacle.

♯♯ *Stems usually coarser, angular and not glaucous. Fruits devoid of bloom. Sepals reflexed.*

Rubus fruticosus, L. Blackberry, Bramble (Fig. 128). Prickly scrambler, or trailing bush.

Flowers in cymes, usually grouped into racemose in-

florescences, with spreading conspicuous white or rosy petals. Homogamous and rich in honey. Fruits black, rarely brown, not pruinose, sweet or acid-sweet, adherent to the receptacle.

[It is impossible to find space here for the numerous varieties and sub-species, founded chiefly on details of

Fig. 128. Blackberry, *Rubus fruticosus*. 1, flowering shoot; 2, vertical section of flower, slightly enlarged; 3, fruit, reduced; 4, floral diagram, p. 315 (Wo).

habit, into which this protean species has been subdivided, and I can merely mention the following groups

in passing: (1) a group including the forms with more erect habit, and glabrous or hairy shoots, with equal prickles, and the sepals pilose or tomentose; (2) a group of forms with the typical arching shoots rooting at the ends, and more or less hairy, with the prickles confined to the angles and nearly equal; (3) a group, also with the typical arching and scrambling shoots, often pubescent or tomentose, glandular and setose; with the larger, unequal, hooked prickles on the angles and smaller ones scattered elsewhere; the leaves frequently hoary beneath; (4) a group remarkable for their hairy, arched shoots, and very unequal and scattered prickles, mingled with setæ and even glandular hairs; (5) a group with more rounded and prostrate shoots, remarkable for their glaucous bloom and unequal prickles. *R. Cæsius* (p. 315) is usually placed here.]

§§ *Fruitlets readily separable from the receptacle. Shoots erect, downy, and with straight setose prickles only.*

Rubus Idæus, L. Raspberry. Flowers small, in axillary and terminal cymes.

Sepals reflexed after flowering; petals smaller, white, erect and approaching at the tips. Flowers homogamous and rich in honey. Fruit red, and easily falling from the receptacle.

□□ *Calyx-tube well developed, urceolate, carrying the insertions of the sepals, petals and stamens high up so that they appear on an epigynous disc, but not closing over above. Homogamous, with little or no honey but abundance of pollen. Pollen ellipsoid, longitudinally striate. The numerous carpels lining the hollow, and ripening to hairy achenes in the "hip"—i.e. the fleshy calyx-tube.* (Rosa.)

† Calyx-tube globose, prickly or bristly.

Rosa villosa, L. Downy Rose. Erect bush with rigid branches, slender, nearly straight prickles, and downy leaves and no glandular hairs.

Flowers few, large, in groups of 1—3, rose-red or rarely white. Sepals persistent, somewhat pinnate, with glandular hairs on the back. Styles free. Fruit globoid, bright red, with erect sepals and small prickles.

†† Calyx-tube devoid of prickles or bristles.

⊙ *Foliage, &c., glandular-hairy and sweet-scented; flowers small, solitary pink. Calyx-tube smooth.*

R. rubiginosa, L. Sweet Briar, Eglantine. Shrub with sub-erect slender branches, with scattered slender hooked prickles mingled with glandular hairs; leaves very glandular beneath, and sweet-scented.

Flowers few, in groups of 1—4, rose-pink, on setose peduncles. Sepals persistent, pinnate; styles free, hairy. Fruit pyriform to sub-globose, with small disc, glabrescent.

⊙⊙ *Foliage not aromatic; calyx-tube smooth.*

▱ *Styles united into a column; calyx-tube globoid; sepals entire, deciduous; flowers white and scentless.*

R. arvensis, L. Field Rose. Stem arched or trailing, with strong, hooked, equal prickles; leaves pubescent, especially beneath.

Flowers pink or white, in groups of 3—6, on prickly and setose peduncles. Sepals reflexed, deciduous, pinnate; styles united into a column. Fruit ovoid, with prominent disc.

▱▱ *Styles free; flowers white or pink.*

§ *Calyx-tube globoid, sepals entire, lanceolate; flowers small and solitary; fruit nearly black.*

R. spinosissima, L. Burnet Rose, Scotch Rose. Dwarf shrub, with short erect branches, and crowded, unequal, subulate prickles; leaflets about 9, small and rounded, simply serrate and glabrous.

Flowers solitary, white, and rather small. Sepals, simple, acuminate, persistent. Styles free. Fruit purple to black with very small disc.

Fig. 129. Dog Rose, *Rosa canina*. 1, flowering shoot; 2, flower in vertical section; 3, the hip, and 4, the true fruit; 5, the latter in section; 6, floral diagram, p. 320 (Wo).

§§ *Calyx-tube ovoid, one or more sepals pinnate, persistent; flowers large, scented, in tufts of* 3—4; *fruit red.*

R. canina, L. Dog Rose (Fig. 129). Stem erect, putting out long sweeping and arching, terete branches, with scattered, strong, equal hooked prickles, smaller above. Flowers large, scented, solitary or in groups of 3—4 on glabrous pedicels, at the ends of the shoots. Sepals reflexed, pinnate, deciduous. Styles free, hairy. Fruit urceolate, ovoid or rounded, with a flat disc.

** Flowers epigynous, the stamens and petals inserted on the margin of the calyx-tube projecting beyond the syncarpous ovary, or on a disc-like swelling on the top of the latter. Carpels few, 1—5, buried in and subsequently fused more or less with the calyx-tube or floral axis.

† Flowers Rosaceous with 2—5 (rarely 1) styles traceable through the epigynous disc, free, or united below.

⊙ *Ovary syncarpous at the base only, the* 2—3 *half-exserted bony carpels and their styles projecting free. Flowers small,* 6—7 *mm. in diameter, drooping.*

Cotoneaster vulgaris, Lindl. Cotoneaster. Rare, low bush, with rounded ovate, pubescent leaves, downy peduncles and calyx-teeth.

Flowers numerous; homogamous, with half-exposed honey, rose-pink, in erect cymes. Calyx-tube cup-shaped, enclosing the carpels at the base only in flower, subsequently creeping up over them. Fruit small, scarlet, pubescent, pendulous.

⊙⊙ *Ovary syncarpous, the carpels entirely submerged. Styles freely projecting. "Fruit" a false berry, the fleshy part entirely due to the calyx-tube.*

▱ *Carpellary walls bony; "fruit" a false berry, the "haw."*

Cratægus Oxycantha, L. Hawthorn, Whitethorn (Fig. 130). Thorny shrub or small tree, with lobed leaves, and

Fig. 130. Hawthorn, *Cratægus Oxycantha*. 1, flowering shoot; 2, fruit; 3, section across latter, p. 321 (Wo).

a peculiar odour in the flowers, due to trimethylamine, which attracts flies; proterogynous, and with half-exposed honey.

Inflorescence a complex corymboid cyme; pedicels glabrous. Calyx-tube urceolate, enclosing the carpels and the greater length of the styles. Calyx-teeth short, lanceolate, reflexed. Petals broad-obovate or sub-rotund, spreading, white or dashed with pink. Stamens 20, or more; anthers purple. Pollen lemon-yellow, ellipsoid, large, 54 μ long, with 3 longitudinal striate folds. Carpels 1—3, each with a long style, not fused on the internal faces but closely invested by the calyx-tube. Fruit the "haw"; a false, berry-like structure composed of the red fleshy calyx-tube investing 1—3 achenes.

▱▱ *Carpellary walls papery, cartilaginous, or parchment-like. Fruit a pome,* 2—5-*celled. Flowers showy.*

§ *Leaves involute. Flowers large,* 30—50 *mm. in diameter and more, in simple cymose tufts. Fruits over* 20—25 *mm. long.*

‡ *Flowers white. Cymes corymbose or racemose. Sepals narrow and pointed. Styles long and free below. Fruit pyriform,* 40—60 *mm. long. Dwarf shoots often thorny.*

Pyrus communis, L. Pear (Fig. 131). Small tree, with elongated fruit.

Flowers on long stalks, in corymboid or racemose cymes of 6—12, giving off an odour of trimethylamine, which attracts flies; proterogynous with half-exposed honey. Calyx-tube enclosing and fusing with the 5 carpels. Styles free. Calyx-teeth erect, then reflexed. Petals rounded, white, clawed. Stamens with purple and eventually black anthers. Fruit narrowed below into the stalk; disc small, surrounded by the ring-like remains of the calyx-teeth. Walls of chambers parchment-like, rounded externally. The Pear is remarkable in culture for the

specialisation of its pollination; many forms absolutely refuse their own pollen, and must have that of other varieties for successful fertilisation.

Fig. 131. Pear, *Pyrus communis*. 1, flowering shoot; 2, vertical section of flower; 3, fruit in section; 4, floral diagram, p. 322 (Wo).

‡‡ *Flowers pink and white; cymes umbellate; styles united below. Fruit 25—30 mm. in diameter, globoid, indented at the base. Sepals broad and downy. No thorns.*

Pyrus Malus, L. Apple, Crab. Small tree, with depressed fruit.

Flowers very large, shortly stalked, in corymboid cymes of 5—6. Proterogynous, with half-exposed honey. Petals

ovate or oblong, red or pink inside, white outside. Anthers yellow. Styles fused half-way. Fruit depressed globoid, indented at base and apex, on short stalks. Chambers acute externally. Cultivated varieties are often barren to their own pollen.

§§ *Leaves not involute but conduplicate. Flowers smaller and more numerous, 10—15 mm. in diameter; in compound corymboid cymes. Pollen like that of* Cratægus, *but smaller. Fruits small and more or less berry-like, 5—15 mm. in diameter.*

‡ *Carpel-walls cartilaginous. Fruit olive-brown, dotted, oblong. Leaves pinnately lobed.*

Pyrus torminalis, Ehr. Service-tree (Fig. 132). Small tree.

Flowers in complex umbellate cymes; stalks and calyx pubescent; petals and anthers white. Calyx-tube hemispherical, enclosing the free styles: calyx-teeth short, triangular, at length connivent. Fruit small, ovoid, brown, berry-like; chamber-walls thin.

‡‡ *Carpel-walls papery. Fruits red, globoid and berry-like.*

÷ *Leaves simple.*

Pyrus Aria, Ehr. Beam Tree, White Beam (Fig. 133). Small tree.

Flowers rather large, in complex umbellate cymes; stalks and calyx white-tomentose; bracts linear, glabrous, scarious. Petals and anthers white, the former spreading. Fruit sub-globose, white-tomentose, especially when young, passing to scarlet, mealy.

Fig. 132. Service-tree, *Pyrus torminalis*, piece of ordinary foliage twig, and two fruits, p. 324 (Sc).

Fig. 133. Beam Tree, *Pyrus Aria*. 1, fruiting branch; 2, flowers; 3, a flower in vertical section, after removal of the sepals; 4, fruit in vertical section, p. 324 (Wi).

÷÷ *Leaves pinnately compound.*

8 *Styles glabrous and fruit globoid.*

Pyrus Aucuparia, Ehr. Rowan, Mountain Ash (Fig. **134**). Small tree.

Flowers in large corymbose and complex cymes,

Fig. 134. Rowan, *Pyrus Aucuparia.* Fruiting branch, p. 327 (Sc).

with pubescent stalks and calyx. Pollen whitish or lemon-yellow, irregular and somewhat polymorphic but mostly rounded or ellipsoid, nearly smooth, about 37 × 25 μ, with 3 longitudinal folds and striate. Styles densely tomentose below. Flowers proterogynous with half-exposed honey. Fruit globoid, scarlet-crimson, berry-like, about as large as a pea, i.e. about 10 mm. in diameter.

8 8 *Styles woolly, fruits slightly pyriform.*

Pyrus Sorbus, Gärtn. Sorb. Very like *P. Aucuparia*, but the leaflets entire up one-third from the base.

The flowers larger, and fewer in the corymb; the pollen more regular, ellipsoid, simple, smooth, with 3 slits and 36 μ, the 5 calyx-lobes more reflexed; and the ovary of 5 carpels and with 5 tomentose styles. The fruit also more pyriform, 5-chambered and about 30 mm. long.

†† Flowers not Rosaceous, the stamens equal in number to the petals; style 1, not traceable through the disc below. Ovary quite inferior.

⊙ *Ovary 1-chambered, with numerous ovules on two parietal placentæ; style deeply bifid. Pollen very polymorphic: quadrangular, pyramidal-truncate, or truncate-conoid, or prismatic and four-angled, or a creased and deformed sphere, 20—30 μ long. Fruit a true berry.* (Ribes.)

▱ *Flowers green, 1—2 together on dwarf shoots; berry yellowish, hairy, 15—25 mm. Spinose bush.*

Ribes Grossularia, L. Gooseberry (Fig. 135). Bush, with pulvinar, and sometimes internodal prickles as well, the former usually trifid.

Flowers pendent in racemose groups of 1—3 on lateral axillary dwarf shoots, with two or three ovate bracts, and

Fig. 135. Gooseberry, *Ribes Grossularia*. 1, flowering shoot; 2, flower in vertical section, enlarged; 3, transverse section of fruit; 4, vertical section of seed, p. 328 (Wo).

a few leaves at the base: protandrous, with partially exposed honey. Calyx-tube campanulate, epigynous, with 5 dull-reddish teeth, at first erect or spreading, then reflexed. Petals smaller, erect, pale greenish-white; stamens included, epigynous, ovary inferior, with several ovules on two parietal placentæ. Style 1; stigma bifid. Berry large ellipsoid or globoid, glabrous, pubescent or glandular; 1—3 cm. long. Crowned with remains of calyx and stamens.

▱▱ *Flowers in pendent racemes; berries glabrous, smooth, small, 8—12 mm. Bush unarmed.*

§ *Pedicels all short, glabrous or nearly so; berry red. Plant not glandular-odoriferous.*

R. rubrum, L. Red Currant. Unarmed bush, with glabrous leaves and flowers.

Flowers small, homogamous, with exposed honey; hermaphrodite, in pendent racemes; stalks glabrous, bracts ovate, twice as long as the slender pedicels. Calyx cup-shaped, yellowish-green or dashed with brown. Pollen pale lemon-yellow, polymorphic, irregularly globoid, deformed and creased, and finely punctate, about 24 μ long. Stigma divided, spreading. Berries as large as a pea, red, thin-skinned.

§§ *Lower pedicels longer, tomentose; berry black, odoriferous with glandular hairs.*

R. nigrum, L. Black Currant. Unarmed bush, with pubescent and glandular leaves and flowers. Flowers rather large, homogamous, with exposed honey; in loose racemes more or less pendent, stalks pubescent or tomentose; bracts subulate, much shorter than the pedicels. Calyx campanulate, green and red, glandular pubescent. Pollen sulphur-yellow, 4-angled, pyramidal or truncate-conoid, or prismatic: the faces plane or curved, finely punctate, about 20 μ. Style terete, capitate. Fruit gland-dotted.

⊙⊙ *Ovary 2—5-chambered; berries black; seeds few.*

▱ *Flowers in simple umbels, greenish. Root-climber with glossy evergreen leaves.*

Hedera Helix, L. Ivy (Fig. 136). Evergreen root-climber, with ovate to broadly 5-angled, highly polished leaves.

Flowers mostly hermaphrodite in simple hemispherical umbels, which are often grouped into racemes at the ends of the branches. With an unpleasant odour,

attracting flies; protandrous, with exposed honey. Calyx-teeth 5, minute. Petals 5, yellowish-green, epigynous.

Fig. 136. Ivy, *Hedera Helix*. 1, flowering shoot; 2, leaf of a barren climbing shoot; 3, flower in vertical section, enlarged; 4, floral diagram; 5, fruit; 6, seed, p. 330 (Wo).

Stamens 5, epigynous. Anthers yellow. Ovary inferior, 5-chambered; style 1, simple, very short. Fruit globoid, as large as a pea, blue-black, pruinose, with green flesh.

□□ *Flowers in dense rounded cymes, cream-white. Not climbing or evergreen.*

Cornus sanguinea, L. Dogwood, Cornel (Fig. 137). Shrub, with red twigs and opposite broadly ovate or oval leaves.

Flowers numerous, homogamous, with exposed honey

Fig. 137. Dogwood, *Cornus sanguinea*. 1, flowering shoot; 2, buds; 3, flower; 4, the same enlarged, after removal of petals and part of style; 5, part of a fruiting cyme; 6, fruit in vertical section, p. 331 (Wi).

on long pedicels, in much branched corymbose cymes, flowering after the leaves appear; flower-stalks, calyx and ovary pubescent. Calyx-teeth 4, short. Petals 4, oblong-lanceolate, radiating cross-wise, white. Stamens 4, epigynous, white. Pollen large, rounded, opaque 63—75 μ in diameter. Disc and anthers yellow. Style terete, expanded above. Fruit globoid, the size of a pea, shining black.

[*Aucuba* also comes here, but its flowers are dicecious, and it is therefore treated on p. 268.]

(b) **Corolla coming off as one whole, not consisting of separately inserted petals** (*Gamopetalæ*).

[Care must be taken in determining this character, since some gamopetalous corollas are so deeply divided that the segments can be torn off separately with little violence—e.g. Holly.]

(i) Ovary superior, the corolla inserted on the floral axis round its base. [For (ii) see p. 342.]

(*a*) *Stamens free from the corolla, or at least not inserted in its tube: hypogynous.* [For (β) see p. 338.]

* Stamens equal in number to the lobes of the corolla—i.e. isostemonous. Anthers not awned. Flowers small, actinomorphic.

† Parts of the flowers in fours. Corolla small, white, rotate, the petals nearly separate. Shrub, with glossy spinescent leaves.

Ilex Aquifolium, L. Holly. The student may find the four white petals just coherent at the base, where the alternate stamens are affixed, and may then look for it as gamopetalous. See p. 288.

†† Corolla small, pink, bell-shaped, five-lobed; stamens 5; ovary 2—3-celled. Procumbent Alpine sub-shrub.

Loiseleuria procumbens, Desv., Creeping Azalea, a rare Alpine plant, with crowded small, opposite, evergreen rolled leaves, and small rose-pink flowers in terminal clusters, has capsules with septicidal dehiscence. Flowers proterogynous, with freely exposed honey.

** Stamens twice as many as the lobes of the corolla; ob-diplostemonous. Median sepal posterior.

[For (††) see p. 337.]

† Flower small, actinomorphic: the corolla urceolate or bell-shaped.

⊙ *Parts of the flower in fours and multiples of* 4, *i.e. tetramerous, throughout; corolla urceolate. Anthers opening by means of pores. Capsules* 4*-celled.*

▱ *Anthers with awns.*

§ *Calyx divided to the base into* 4 *scarious, rosy sepals; longer than the persistent corolla. Capsule septicidal.*

Calluna vulgaris, Salisb. Ling. Prostrate or ascending shrub with persistent foliage, becoming red-brown in winter; the decussate small leaves closely imbricated.

Flowers small and numerous, in terminal and lateral secund spikes, shortly pedicelled, drooping, slightly protandrous, the honey hidden at the base of the corolla. Calyx 4-partite, rosy, longer than corolla, and embracing it completely; with 4 basal bracts. Corolla bell-shaped, deeply 4-cleft, persistent, rose, fading to red-brown, enclosing the capsule. Capsule 4-celled, septifragal.

§§ *Calyx deeply divided into 4 lobes, shorter than the corolla: stamens included. Flowers protandrous, the honey hidden at the base of the corolla: pollinated by bees. Capsule loculicidal.* (Erica.)

‡ *Flowers many, in evident racemes. Awns of anthers very short and tooth-like. Ovary glabrous. Leaves mostly in whorls of three.*

Erica cinerea, L. Bell Heather. Small sub-shrub, with minute linear leaves in crowded whorls of 3 or 4, lamina glabrous, furrowed beneath.

Flowers in dense, elongated, terminal racemes, reddish-purple. Calyx deeply 4-partite; sepals linear-lanceolate. Corolla ovoid, slightly 4-lobed, rosy-purple fading to bluish-lilac. Ovary glabrous. Capsule 4-chambered, septicidal.

‡‡ *Flowers clustered into terminal umbels. Awns of anthers long and subulate. Ovary pubescent. Leaves chiefly in whorls of four.*

Erica tetralix, L. Cross-leaved Heath. Differs from *E. cinerea* in its cruciate, whorled, downy and ciliate linear revolute leaves, terminal umbellate clusters of pinker flowers, and pubescent ovary.

[The rare *Erica ciliaris*, *E. carnea*, and *E. vagans* also come here, but their anthers are devoid of awns. *E. ciliaris* has the anthers included, and is ciliated. In the other two the anthers protrude slightly from the corolla; the filaments are flattened in *E. carnea*, but not in *E. vagans*.]

▱▱ *Anthers devoid of awns. Capsule septicidal, leaving the persistent axis.*

Menziesia polifolia, St Daboec's Heath, is a rare Irish plant.

[The still rarer *M. cærulea* has the parts of the flowers in fives.]

⊙⊙ *Parts of the flower in fives and multiples of 5; i.e. pentamerous throughout, anthers with awns.*

▱ *Fruit capsular.*

Andromeda polifolia, L. Marsh Andromeda. A rare prostrate sub-shrub, with oblong-lanceolate, evergreen, revolute leaves, glaucous beneath.

Flowers like *rbutus*, but the fruit capsular with loculicidal dehiscence. Flowers homogamous, with hidden honey.

▱▱ *Fruit fleshy and berry-like.*

§ *Tall shrub. Several ovules in each cell of the ovary. Fruit a warted red berry.*

Arbutus Unedo, L. Strawberry-tree. Evergreen shrub, or small tree, with red-brown stem, leathery, shining, oblong-lanceolate leaves, and fruits curiously marked and coloured in superficial resemblance to a strawberry. Bee-flowers.

Flowers in dense, pendent, terminal panicles, each flower subtended by an oblong bract. Calyx 5-lobed. Corolla white or rosy, pellucid, inodorous, 5—10 mm. long; urceolate with reflexed teeth, deciduous. Stamens 10, hypogynous, as is also the disc; filaments flattened below, hairy. Anthers opening by pores, compressed, dorsifixed, with two reflexed terminal appendages. Pollen in tetrahedral groups of 4, with pores on the corners. Fruit red, stalked, pendent, globoid, as large as a cherry or strawberry, warted, acid-sweet; ripening the second year, so that all stages may occur simultaneously.

The floral formula is $K_5 C_{(5)} A 5 + 5 G(\underline{5})$, the stamens sub-diplostemonous.

[The resemblance of the fruit to a Strawberry is purely superficial, the wart-like excrescences being on the carpellary walls, and the seeds enclosed in the fleshy fruit; whereas in the Strawberry the flesh is the floral axis and the "pips" the achenes (fruits) borne on it.]

§§ *Procumbent sub-shrub. Ovary-cells each with one ovule. Fruit a small red smooth berry.*

Arctostaphylos Uva-ursi, Spreng. Bear-berry. A procumbent evergreen sub-shrub, with Box-like leaves and Cranberry-like habit.

Flowers homogamous with hidden honey; like those of *Arbutus*, but smaller, and red berries like those of the Cranberry, but the ovary is superior.

[The much rarer *Arctostaphylos alpina* has narrower, thinner leaves, withering in autumn, and black berries.]

†† Flowers large, 50—60 mm. or more long, zygomorphic. Parts of flowers in fives or multiples of 5. Median sepal anterior. Anthers devoid of awns, opening by apical pores; pollen connected by fine threads: Capsule septicidal.

⊙ *Flowers yellow, very fragrant, viscous. Stamens* 5. *Leaves deciduous and hairy.*

Azalea pontica, L. Yellow Azalea. Shrub with deciduous, ciliate and clammy leaves, and large, fragrant, yellow flowers in terminal umbellate clusters, appearing before the foliage. Protandrous, with abundance of honey.

Calyx short, glandular-viscid, irregularly 5-lobed. Corolla with a long grooved tube, glandular-viscid, and a spreading limb divided into 5 irregularly ovate-lanceo-

late, wrinkled and slightly undulated segments, three of which are erect, the other two downwards and forwards, so that the corolla appears almost 2-lipped; yellow, the upper more or less spotted with orange. Stamens 5, exserted, sweeping forwards and upwards: anthers orange; pollen whitish and held together with arachnoid threads. Ovary angular, cylindroid-conic, hairy: style long, filiform, sweeping forwards and upwards beyond the stamens; stigma green, capitate.

⊙⊙ *Flowers purple, neither fragrant nor very viscid. Stamens* 10. *Leaves glossy and evergreen.*

Rhododendron ponticum, L. Rose Bay. Shrub, with glossy evergreen, broadly lanceolate leaves, and purple flowers in terminal tufts.

Flowers protandrous, with abundance of honey. Calyx short, irregularly 5-lobed. Corolla almost bi-labiate; the tube short, the limb deeply divided into 5 rounded, oblong, undulating segments, of which three are erect and two sweeping forwards; reddish-purple, striate, the upper middle segment marked with numerous red-orange spots. Stamens 10, long, filamentous, pink, sweeping forwards and upwards; anthers red; pollen smooth, in tetrahedral groups of 4. Style long, filamentous, red, projecting beyond the stamens, the upturned end terminating in a pink capitate stigma. Ovary cylindroid, angular, with 5 cells and numerous small ovules on axile placentæ. Capsule septicidal and septifragal.

(β) *Stamens on the corolla-tube—i. e. epipetalous; as many as, or fewer than, its lobes. Ovary two-celled. Flowers regular.*

[For (**) see p. 341.]

* Stamens 2. Corolla and calyx each 4-lobed, valvate in buds; flowers in terminal thyr-

soid cymes, small, regular and numerous. Leaves opposite.

† Corolla salver-shaped, lilac, with long tube; fruit a capsule; seeds slightly winged.

Syringa vulgaris, L. Lilac (Fig. 138). Shrub, with opposite cordate leaves, and branches falsely dichotomous owing to the abortion of the terminal buds.

Fig. 138. Lilac, *Syringa vulgaris*. 1, leaf; 2, inflorescence; 3, flower; 4, upper part of the corolla in vertical section; 5, anther; 6, stigma; 7, ovary in vertical section; 8, capsule, p. 339 (Wo).

Flowers in large, loose cymose panicles, up to 15—16 cm. long, each branch terminating in a flower; lilac-purple and fragrant. Homogamous, with the honey hidden in the tube. Calyx short, tubular, 4-lobed, persistent. Corolla salver-shaped, with a long tube and 4-partite limb, the

lobes spreading cross-wise. Stamens 2, sub-sessile in the throat of the corolla, alternate with the lobes. Style 1: stigma bifid, ovary superior, 2-chambered. Fruit a two-valved capsule.

†† Corolla funnel-shaped, tube short, white: fruit a berry; seeds not winged.

Ligustrum vulgare, L. Privet (Fig. 139). Much-branched shrub, with sub-evergreen lanceolate leaves.

Fig. 139. Privet, *Ligustrum vulgare*. 1, flowering shoot; 2, a flower, and 3, vertical section through it, enlarged; 4, fruit, and 5, section across the same; 6, seed, p. 340 (Wo).

Flowers homogamous, with the honey hidden in the tube: in pyramidal panicles, up to 8 cm. long, odorous; similar in structure to those of the Lilac, but the corolla smaller, white, and with less spreading lobes. Fruit fleshy, shining black, about the size of a pea, with purple flesh; persistent through the winter.

[The Ash, *Fraxinus excelsior*, also belongs to the same Natural Order (*Oleaceæ*) as the Privet and Lilac, but it is abnormal in its polygamy and in having no calyx or corolla (see p. 275): the latter are present in other species, however.]

** Stamens 5, equal in number to the corolla-lobes, which are purple-bluish or lilac, and not valvate in bud. Leaves not opposite.

† Flowers in small umbellate lateral or leaf-opposed cymes; corolla blue, rotate, with short tube; stamens sub-sessile; anthers long and conniving into a central yellow cone, opening by apical pores.

Solanum Dulcamara, L. Bittersweet. Sub-shrub, with scrambling or climbing shoots and the leaves and inflorescences often displaced.

Flowers drooping, homogamous and devoid of honey; on slender pedicels. Calyx 5-fid, the lobes broad and obtuse. Corolla purple-blue, with five revolute lobes, each with a pair of greenish spots at its base which are visited by insects; about 12—15 mm. in diameter. Stamens 5, sub-sessile; anthers yellow, long and tapering, coherent into a cone, with apical pores. Ovary 2-celled, with many ovules: style simple, stigma blunt. Berry red. Pollen white, very small, rounded to ellipsoid-fusiform, with 3 longitudinal grooves, smooth, about 15 × 10—12 μ.

†† Flowers axillary, single or few together; corolla funnel-shaped, pale bluish-lilac, 16—22 mm. across, the tube as long as the lobes, 7—10 mm.; throat hairy. Stamens long, anthers small, not connivent, opening by slits.

Lycium barbarum, L. Tea Tree. More or less thorny straggling bush with slender arching branches. The popular name is owing to a misconception when the plant was introduced, as it has nothing in common with the true Tea Plant.

Flowers single or in small cymose tufts in the leaf-axils, on long slender pedicels. Homogamous, with honey in the tube. Calyx more or less two-lipped, the 5 lobes ovate. Corolla funnel-shaped, the tube as long as limb, which is about 10—12 mm. across, hairy at the margin, its lobes ovate-oblong, bluish or lilac changing to greenish-yellow at the base inside. Stamens 5, somewhat exserted, spreading; filaments long and slender, anthers dehiscing by slits. Ovary 2-celled; style filiform, stigma dilated. Berry oblong, red.

(ii) Ovary completely inferior; corolla epigynous.

[For (β) see p. 343.]

(*a*) *Stamens not inserted on the corolla; flower regular, and the parts in fours or fives or multiples of* 4 *or* 5. *Stamens ob-diplostemonous, opening by pores. Fruit baccate. Moorland sub-shrubs* (Vaccinium *type*).

* Parts of the flower in fives; corolla subglobose, urceolate; stamens 10; anthers awned; flowers homogamous, with honey at the base of the corolla; berries blue-black. Leaves deciduous.

† Branches angular and leaves serratulate, and not glaucous. Corolla white, touched with green and rose, 6—7 mm. long.

Vaccinium Myrtillus, L. Bilberry, Whortleberry. Glabrous sub-shrub, with angular ascending branches, and deciduous, ovate, serratulate leaves.

Flowers single, pendent on short axillary pedicels. Calyx an epigynous angular rim. Corolla urceolate-globoid, pale greenish-white dashed with red, with 5 small teeth. Ovary inferior. Fruit globoid, blue-black pruinose, about as large as a pea.

†† Branches rounded; leaves entire and glaucous beneath. Corolla pink, 4—5 mm. long.

Vaccinium uliginosum, the Bog Whortleberry, is very similar to the last, but the branches are not angular; the leaves are entire and more obovate, and glaucous beneath; and the flowers smaller.

** Parts of the flower in fours, stamens 8; corolla bell-shaped; anthers not awned; berry red. Leaves evergreen.

[The rarer *Vaccinium Oxycoccus*, the Cranberry, with evergreen ovate pointed leaves and scarlet berries; and *V. Vitis-idæa*, the Red Whortleberry or Cowberry, with Box-like leaves, and Cranberry-like berries, also come here.]

(β) *Stamens inserted on the corolla-tube—i. e. epipetalous. Anthers with neither awns nor pores. Parts of calyx and corolla, and stamens, 5 each: ovary 2—3-celled.*

* Flowers regular and actinomorphic. Shrubs not climbing. [For (**) see p. 347.]

† Corolla bell-shaped, rosy; stamens inserted;

flowers axillary in leafy racemes; berries white.

Symphoricarpos racemosus, Mchx. Snowberry. Straggling shrub, often planted in hedgerows and shrubberies.

Flowers small, homogamous, with honey in the tube; sub-sessile in opposite pairs; grouped in terminal and axillary racemose bunches of two or three to half-a-dozen or more, each subtended by about two minute bracteoles. Calyx-limb 5-toothed. Corolla rosy, of spongy texture, campanulate, about 5—6 mm. long, cut half-way into five obtuse lobes; throat hairy, tube filled with honey. Stamens 5, included; filaments short, inserted high up the tube, as is also the glabrous style; stigma dilated. Ovary 4-celled, ovoid, with abortive ovules in two of the cells. One ovule in each of the others. Fruit white, pulpy, globoid, two-celled by abortion; hanging on the bush far into the winter. Seed reniform and smaller than its cell.

†† Corolla white, not bell-shaped; stamens more or less exserted; flowers in much-branched cymes; berries not white.

⊙ *Ovary with 3 sessile stigmas; fruit a drupaceous berry, black; leaves pinnate. Corolla rotate.*

Sambucus nigra, L. Elder (Fig. 140). Shrub or small tree, with opposite pinnate leaves. Flowers small, in large, flat, terminal, erect, much-branched and long-stalked corymboid cymes; homogamous, devoid of honey, with strong peculiar odour. Corolla rotate, yellowish- or cream-white. Stamens 5, alternating with the corolla-lobes. Pollen ellipsoid-fusiform, smooth, with 3 furrows. Ovary superior, 3-chambered; style short; stigmas 3. Berries globoid, about as large as a small pea, shining black.

Fig. 140. Elder, *Sambucus nigra*. 1, flowering shoot; 2, flower in vertical section, enlarged; 3, fruit; 4, floral diagram, p. 344 (Wo).

⊙⊙ *Ovary with 3 short styles; fruit a drupe; simple.*

▱ *Flowers all alike, small and perfect; corolla shortly funnel-shaped; stamens hardly exserted; drupe flattened, black.*

Viburnum Lantana, L. Wayfaring Tree. Shrub, with opposite mealy leaves. Flowers in dense flat-topped corymboid cymes, all alike, small and hermaphrodite. Homogamous, with exposed honey, and strong odour. Corolla white, regular. Stigmas 3, sessile. Fruit oval, compressed, mealy, passing through red to black.

▱▱ *Corolla rotate; outer flowers of the cyme with larger corollas, and devoid of functional stamens and pistil; drupe globose, red.*

V. Opulus, L. Guelder Rose (Fig. 141). Shrub, with

Fig. 141. Guelder Rose, *Viburnum Opulus*. 1, flowering shoot; 2, a barren, and 3, a hermaphrodite flower; 4, portion of fruiting cyme; 5 and 6, kernel in vertical and transverse section, p. 346 (Wi).

opposite, lobed leaves, the petioles glandular above and with fimbriate stipules below. Flowers white, in much-branched and extended, flat corymboid cymes; those at the periphery barren, and with large, sub-rotate, slightly irregular corollas; the remainder hermaphrodite, with small, regular, tubular corolla. Homogamous, with exposed honey. Stamens 5, alternate with the corolla-lobes, and exserted. Stigmas 3, sessile. Fruit ovoid, fleshy, scarlet.

** Corolla zygomorphic, with a long tube and two-lipped limb, glandular pubescent.

† Flowers crowded in terminal heads; corolla 30—50 mm. with long tube, red outside, yellow within. Plants twining.

⊙ *Heads of flowers peduncled.*

Lonicera Periclymenum, L. Honeysuckle, Woodbine. Twining plant, with opposite, petiolate, more or less elliptical leaves, and yellow fragrant flowers. Protandrous, homogamous and strongly scented in the evening, when the moths pollinate them. Flowers yellowish-white dashed with red passing to dull yellow; in terminal long-stalked clusters of dichasia. Calyx, bracts and long peduncles glandular pubescent. Pollen spheroidal, echinulate, drying to tetrads. Berries red: the pericarp, placenta, bracts and axis becoming fleshy, but the fruits not fusing.

⊙⊙ *Heads of flowers sessile in the leaf-axils.*

Lonicera Caprifolium, L. Perfoliate Honeysuckle (Fig. 142). Twining, and much resembling *L. Periclymenum*, but the flowers are sessile in terminal whorls in the axils of the uppermost connate leaves. Pollinated by moths as in the case of *L. Periclymenum*. Corolla 2—2·5 cm. long, tubular,

curved, the limb cut into a 4-lobed upper and a single lower lip, glabrous; tube white and red passing to yellow. Stamens and filamentous green style exserted. Berry globoid, orange-scarlet.

Fig. 142. Perfoliate Honeysuckle, *Lonicera Caprifolium*. 1, flowering shoot; 2, floral diagram; 3, ovary in vertical section; 4, cluster of fruits, p. 347 (Wo).

†† Flowers in pairs on short axillary stalks; corolla with shorter tube, 15 cm. or so, yellow.

Lonicera Xylosteum, L. Fly Honeysuckle. Erect shrub,

with the flowers in pairs on axillary peduncles, and the pairs of fruits half-concrescent, and the leaves and corollas softly hairy. Homogamous, with honey hidden in the tube: pollinated by bees. Peduncle 1·5 cm. long; corolla about the same length, slightly 2-lipped, white to yellow dashed with red, downy outside. Calyx-limb deciduous. Stamens downy, exserted, curved, green, with yellow anthers. Style downy. Berries globoid, about the size of a pea, purple-red, fused below in pairs, bitter.

APPENDIX.

THE Willows offer such peculiar difficulties, owing to their being dicœcious (apart from the even greater difficulties of their hybrids and varieties, which cannot be touched on here), that I have drawn up the two following schemes to facilitate diagnosis when the flowers of one sex only are available. These tables may then be employed in connection with the scheme of classification given above.

A. CLASSIFICATION OF WILLOWS WHEN ♀ CATKINS ALONE ARE AVAILABLE.

(1) **Catkins terminal or sub-terminal *on the* current shoots, pedunculate; dwarf or creeping rare northern plants.**

(a) **Catkins short (rarely to 25 × 5 mm.) with a long, hairy peduncle, 8—22 × 4—5 mm.; scales velvety-ciliate, concolor, persistent; capsule sub-sessile, hairy; style short; gland 1, bifid or urceolate and slit so as to look like 3—4; leaves small, on long petioles, rounded and reticulate. Branches smooth, short.**

Salix reticulata, p. 206.

(b) **Peduncle short, catkin 10 × 5 mm. Scales glabrescent-ciliate, discolor or hardly so; gland 1, posterior; capsule sub-sessile, glabrous; style short; leaves petiolate rounded, glabrous, with pellucid venation. Dwarf willow, with small catkins, loose-flowered, immersed in leafy ends of the shoots. Scales concolor.**

Salix herbacea, p. 206.

(2) Catkins lateral on last year's shoots.

(a) Scales concolor and of a pale yellowish or greenish hue. Catkins large, rarely less than 30—70 × 6—10 mm. as they pass into fruit. Shrubs or trees.

(i) Scales persistent and velvety-ciliate; capsule pedicellate, glabrous; style short. One posterior gland. Pedicel of ovary as long as the ovary, and 5—6 times as long as the gland. Stigmas thick, divaricate, sessile: style 0. Flowering catkins 30—70 × 5—6 mm. Leaf glabrous.

Salix triandra, p. 213.

(ii) Scales caducous; style short; ovary glabrous.

(*a*) *Scales glabrescent; leaves lanceolate glabrescent, and pendent. Catkin* 20—40 × 5—7 *mm. Leaf hardly hairy and often twisted. Ovary sessile, glabrous; stigma thick and spreading, sub-sessile. Catkin-scales concolor; with one broad posterior gland.*

Salix Babylonica, p. 209.

(*β*) *Scales hairy-velvety or silky-ciliate.*

* Ovary sessile; leaves lanceolate, silky beneath, the hairs parallel to the midrib. Catkin 50—60 × 6—8 mm. Gland 1. Leaf silky, otherwise much as in *S. Babylonica*. The glands broad. Scales concolor.

Salix alba, p. 211.

** Ovary with the pedicel longer than the nectary; leaves glabrous; glands 2.

† Leaves narrow lanceolate; petiole occasionally

with 2 glands. Twigs fragile at the articulations. Shrub or tree. Leaves of the catkin-peduncle almost entire. Catkin usually at least 25 × 8 mm. (20—60 × 6—10 mm.). One anterior and one posterior gland. Scales concolor.

Salix fragilis, p. 209.

†† Leaves broad and shining; petiole glandular. Twigs not fragile. Shrub or tree. Catkin-scales entire; leaves of the peduncle distinct, and finely toothed. Catkin usually at least 25 × 8 mm. (20—65 × 7—12 mm.); glands 2, one anterior and one posterior. Scales concolor.

Salix pentandra, p. 211.

(b) Scales discolor, the proximal moiety pale, the distal purple-brown to black; persistent.

(i) Style long; ovary sessile or sub-sessile. Gland 1.

(*a*) *Ovary glabrous. Catkin* 25—50 × 8—12 *mm. Branches pruinose. Ovary sub-sessile, with the style nearly as long; stigmas thick and hardly divergent. Scales discolor. One posterior gland.*

Salix daphnoides, p. 215.

(*β*) *Ovary hairy.*

* Leaves very narrow. Catkins 20—30 × 8—14 mm. Osier shrubs. Catkins appearing before the leaves. Style as long as the fat-ovoid, villous, short-stalked ovary. Stigmas slender, bifid and spreading. Scales discolor. One posterior gland.

Salix viminalis, p. 218.

** Leaves not very narrow. Dwarf or creeping, rare northern species.

† Leaves glabrous or glabrescent, with venation distinct.

⊙ *Catkins* 12—20 × 6—8 *mm. Branches spread or prostrate and velvety at the tips. Gland long and thin. Catkins and leaves slightly hairy, the former appearing with the foliage. Style as long as the ovary; ovary sessile, hairy; stigmas bifid. Scales discolor. Gland one, posterior.*

Salix Myrsinites, p. 207.

⊙⊙ *Catkins* 15—30 × 5—8 *mm. Branches shining and grouped into a crown. Gland undivided, long and thin. Stigma on a short bifid style. Ovary very hairy and sub-sessile. Scales discolor. One posterior gland.*

Salix arbuscula, p. 208.

†† Leaves silky and the venation more or less hidden.

⊙ *Catkins* 20—30 × 10 *mm. Gland short. Catkins and leaves slightly hairy, the former appearing with the leaves. Style as long as the ovary, hairy; stigmas bifid. Scales discolor. One posterior gland.*

Salix Lapponum, p. 208.

⊙⊙ *Catkins large*, 20—50 × 15 *mm., or more. Leaves and catkins with a golden shimmer. Catkins sessile, appearing before the leaves, in tufts of* 2—4 *at the ends of the shoots; with at most a few basal leaves. Branches not pruinose. Ovary sessile, glabrous; style medium, with two slender bifid divaricate stigmas. Scales discolor. One posterior gland.*

Salix lanata, p. 208.

(ii) Style short; ovary hairy or at least glabrescent. Gland 1.

(*a*) *Ovary sessile; leaves sub-opposite. Catkins* 15—45×6—8 *mm. Ovary fat-ovoid, blunt, hairy; with sessile, small and broad stigma. One short broad posterior gland. Scales discolor.*

Salix purpurea, p. 216.

(*β*) *Ovary pedicellate; leaves alternate.*

* Dwarf creeping plant with silky leaves and small catkins 5—12 × 5—8 mm., usually at most 2 : 1. Pedicel of ovary at least 3—4 times as long as the gland, and, like the ovary, villous. Style obsolete; stigmas divaricate and minute. One posterior gland. Scales discolor.

Salix repens, p. 207.

** Plants not creeping or dwarf.

† Leaves black on drying, glabrous or slightly pubescent; catkins 10—25 × 6—12. Catkins with or before the foliage, thick and short. Branches more or less shortly hairy. Catkins serially on the long shoots. Leaves only loosely hairy, or glabrous. Pedicel of the ovary about twice as long as the one short posterior gland, and like the ovary, glabrous or hardly hairy. Scales discolor. Style short, about as long as the stigma.

Salix nigricans, p. 219.

†† Leaves brown on drying.

⊙ *Leaves glaucous or bluish beneath, not rugose, with prominent venation. Catkins* 15—35 ×

8—12 *mm.* *Details as in* S. nigricans *but the ovary is here hairy.*

Salix phylicifolia, p. 220.

⊙⊙ *Leaves rugose or chagreened above, velvety or tomentose beneath, with prominent venation.*

▱ *Leaves small, about* 2—5 × 1—3 *cm., obovate, chagreened above. Catkins small,* 6—20 *mm. long. Stigmas spreading. Shoots finely pubescent. Catkins at least* 3 : 1. *Pedicel of the ovary* 5—6 *times as long as the gland. Catkins serially on the long shoots, and appearing with the leaves; thickish and short. Ovary and pedicel glabrous. Style obsolete. Scales discolor. One posterior gland.*

Salix aurita, p. 221.

▱▱ *Leaves large, at least* 5—9 × 2—5 *cm., ovate.*

§ *Stigmas not diverging. Shoots finely pubescent. Catkins* 15—40 × 12—26 *mm. Pedicel of ovary* 5—6 *times as long as the gland. Ovary smooth. Scales discolor. Only one posterior gland.*

Salix Caprea, p. 221.

§§ *Leaves not shimmering hairy. Catkins* 20—40 × 10—18 *mm. Shoots tomentose. Pedicel of ovary* 2—3 *times as long as the gland, hairy, as is the ovary. Only one posterior gland. Scales discolor.*

Salix cinerea, p. 220.

B. Classification of Willows when ♂ catkins alone are available.

(1) Stamens five—or occasionally more, hairy at the base; two glands in each ♂ flower. Petiole glandular.

Salix pentandra, p. 211.

(2) Stamens fewer than five.

(a) Stamens three, glabrous; two glands in each ♂ flower. Petiole glandular.

Salix triandra, p. 213.

(b) Stamens not more than two.

(i) Stamens two, as shown by the 4 anther-lobes; but so closely fused as to appear one; hairy at the base. One gland only to each ♂ flower. Many of the leaves opposite.

Salix purpurea, p. 216.

(ii) Stamens two, free.

(*a*) *Glands two in each ♂ flower; scales concolor or nearly so, and caducous; catkins stalked.*

* Stamens hairy; catkins lateral, large, 20—50 × 6—12 mm., with leafy stalk; leaves lanceolate.

† Leaves silky pubescent; tree not weeping.

Salix alba, p. 211.

†† Leaves not silky.

⊙ *Branches pendent.*

Salix Babylonica, p. 209.

⊙⊙ *Branches cracking at the articulations. Catkins shortly stalked, many-flowered, 20—45 × 7—12 mm., serially on the long shoots. Scales concolor.*

Salix fragilis, p. 209.

** Stamens glabrous; catkins small, 4—8 × 4—6 mm., sub-terminal, hardly leafy; leaves small and broad-ovate. Dwarf plant. Catkins few-flowered in 1—2—3 on short lateral shoots. Two equal glands in each ♂ flower. Scale ciliate, but nearly glabrous, concolor.

Salix herbacea, p. 206.

(β) *Only one gland in each ♂ flower.*

* Catkins small, rarely above 5—15 mm. long. (See also *Salix aurita*, p. 221, and *Salix nigricans*, p. 219.) Plants dwarf or prostrate, creeping, &c. Mostly rare northern forms. See also *Salix lanata*, and *Salix Lapponum*, p. 208.

† Scales concolor, velvety; peduncle long, villous, and sub-terminal. Leaves small. Stamens hairy at the base. Catkins few-flowered, 10—12 × 5—6 mm. In 1—2—3 on short lateral shoots. Dwarf scales. Concolor. Venation netted.

Salix reticulata, p. 206.

†† Scales discolor and hairy; peduncle short or at least not very long, leafy, lateral; venation not prominently reticulate.

⊙ *Catkins fairly large, appearing with the leaves and on distinct leafy peduncles; several one over the other on the long shoots. Stamens smooth, free. Anthers violet before anthesis; gland long and narrow, one, pos-*

terior. Peduncle fairly long, leafy; leaves elliptic or lanceolate, gland-toothed. Shoots glabrous.

Salix Myrsinites, p. 207.

⊙⊙ *Anthers yellow before anthesis.*

▱ *Catkins appearing before the leaves, with leafy bracts. Leaves entire, silky at least beneath, peduncle obsolete. Catkin short, sub-globoid, rarely up to* 15 *mm.* (6—16 × 6—12). *Branches not pruinose. Stamens glabrous, free. Scales discolor. Only one posterior gland.*

Salix repens, p. 207.

▱▱ *Catkins almost terminal and peduncle distinct with a few leaves; with the leaves or later. The one, posterior, gland long and narrow. Leaves glabrous; peduncle moderate, leafy. Catkins several, fairly large, one over the other on the long shoots. Stamens smooth; free. Shoots glabrous.*

Salix arbuscula, p. 208.

** Catkins lateral, large, rarely less than 25—60 mm. long (see *S. aurita* and *S. nigricans*). Shrubs or trees rarely dwarf, or rare northern species (see *S. Lapponum* and *S. lanata*). Scales hairy and discolor. Anthers yellow before, brown after anthesis.

† Stamens villous at the base. Catkins lateral, sessile, not leafy but with a few small scales or bracts at base.

⊙ *Catkins at least* 20—30 × 12—20 *mm. with basal scale-leaves. Catkins several, one over the other on the long shoots. Sessile, appearing before the leaves. Long, but not over*

6—8 : 1. *Branches tomentose. Leaves elliptical-lanceolate to obovate* 5—8 (—12) × 2—4·5 *cm. Grey-tomentose beneath, rugose with prominent venation.*

Salix cinerea, p. 220.

⊙⊙ *Catkins not more than* 6—20 *mm. long, several one over the other on long shoots, sessile, appearing before the foliage. Long, but not more than* 6—8 : 1 *or so. With a few small basal scale-leaves. Branches very divergent and angular, smooth or glabrescent. Leaves like* S. cinerea, *but much smaller* (2—5 (—7) × 1—3 *cm.*), *chagreened above, velvety and reticulate beneath.*

Salix aurita, p. 221.

[The stamens of *S. nigricans* are occasionally provided with a few hairs at the base, and those of *S. Caprea* are sometimes rather glabrescent.]

†† Stamens glabrous.

⊙ *Catkins distinctly pedunculate, and with a few leaves, rather crowded towards the tips of the branches;* 20—30 × 10 *mm.; sweet-scented—the one, posterior gland long and narrow. Leaves silky-tomentose. Shoots glabrous. Stamens smooth, free.*

Salix Lapponum, p. 208.

[The very rare arctic species, *Salix lanata*, also comes here. It has more ovate densely silky-woolly leaves, with a glistening golden shimmer like the catkins. The latter are crowded 2—4 together at the ends of the shoots, sessile, with at most a few basal scales, and appear before the leaves; they are about 20—50 × 15 cm. Stamens two, smooth, free. One posterior gland only. Scales discolor.]

⊙⊙ *Catkins sessile or sub-sessile, not leafy but with a few bracts or scales below; lateral on the long shoots.*

▱ *Second and third year branches purple-pruinose, with yellow inner cortex. Catkins* 30—60 × 15—30 *mm.*

Salix daphnoides, p. 215.

▱▱ *Branches not purple-pruinose.*

§ *Leaves very narrow, linear-lanceolate, wavy, at least* 12—15 *times as long as broad; silky beneath, the hairs parallel to the secondaries. Catkins sessile,* 20—30 × 12—18 *mm., with scales or a few very young leaves at the base; several one over the other on the long shoots. Appearing before the foliage. Long. Stamens smooth, free. Scales discolor. Only one, posterior scale.*

Salix viminalis, p. 218.

§§ *Leaves not very narrow and not more than about twice as long as broad; more or less elliptical or obovate, and not silky beneath.*

♯ *Catkins not more than* 10—25 × 8—16 *cm., sessile, appearing before the leaves, with a few small scale-like leaves at the base; several one over the other on the long shoots. Long, but not over* 6—8 : 1. *Branches villous or tomentose; leaves glabrous, or at most pubescent; blackening on drying. Stamens smooth: rarely with a few hairs at base.*

Salix nigricans, p. 219.

‡‡ *Catkins rarely less than* 25—30 × 12—25 *cm. Leaves not black, but brown on drying.*

÷ *Catkins* 30—50 × 18—25 *cm. Leaves rugose with prominent venation and pubescent beneath. Stamens smooth or glabrescent. A few small scale-leaves at the base of the catkins, which are arranged one over the other on the long shoots. Appearing before the leaves; sessile, long, but not over* 6—8 : 1.

Salix Caprea, p. 221.

÷ ÷ *Catkins* 20—25 × 12—15 *cm., gland short and broad. Leaves not rugose, glaucous or bluish beneath, and the venation not very prominent. Shoots glabrous. Catkin distinctly stalked, large, with leaves at the base, several one over the other on the long shoots. Stamens smooth, free. Scales bicolor. Only one, posterior gland.*

Salix phylicifolia, p. 220.

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GLOSSARY.

The following conventional signs are used throughout the book:

♂	staminate or male.			
♀	pistillate or female.			
☿	hermaphrodite or bisexual.			
K	(in floral formula)			Calyx.
C	,,	,,	,,	Corolla.
A	,,	,,	,,	Androecium.
G	,,	,,	,,	Pistil.
↯	,,	,,	,,	Zygomorphic.
|	,,	,,	,,	Ob-diplostemonous.
( )	,,	,,	,,	Union of parts.
—	,,	,,	,,	indicates superior if below, inferior if above, the ovary.
⌣	indicates adhesion.			
√	,,			the root or type number.

Abortion, failure to complete development.

Accessory, additional or superfluous to the normal, p. 37.

Accrescent, of a calyx which goes on growing as the fruit ripens, p. 75.

Achene, an indehiscent, one-seeded fruit, p. 233.

Achlamydeous, devoid of both calyx and corolla, or perianth of any kind, p. 67.

Acicular, needle-shaped, p. 195.

Acropetal, when the order of development is such that the youngest organ is nearest the apex of the shoot.

Actinomorphic, with parts radiately grouped so that the flower can be cut in two or more planes into symmetrical halves, p. 74.

Acuminate, drawn out to a long point.

Acyclic, not in cycles, but in spirals, p. 56.

Adhesion, concrescence of organs of unlike kind, p. 61.

Adnate, joined for some distance up to another organ.

Æstivation, the arrangement of the petals, &c., in bud, p. 146.

Alæ, same as Wings.

Alveolate, pitted with honeycomb-like depressions, p. 292.

Anatropous, of an ovule, curved over on its raphe so completely that the micropyle comes close to the junction with the stalk, p. 114.

Androdioecious, where ☿ and pseudo-hermaphrodite ♂ flowers occur on different plants, p. 161.

Androecium, the totality of the stamens in one flower, p. 43.

Andromonoecious, where ☿ and pseudo-hermaphrodite ♂ flowers occur on the same plant, p. 161.

Anemophilous, pollinated by the wind, p. 156.

Anemophily, where pollination is due to the agency of wind, p. 156.

Antero-basal, at the forward edge of the basal part of the carpel, &c., p. 51.

Anther, that part of the stamen in which the pollen is developed, p. 82.

Antheridium, the ♂ organ of certain Cryptogams.

Antherozoid, the motile ♂ element of certain Cryptogams.

Anthesis, the opening of the flower.

Antipetalous, opposite the petals.

Antipodal cells, certain naked nucleated cells at the base of the embryo-sac in Angiosperms.

Apetalous, devoid of petals.

Apocarpous, with free separate carpels, p. 65.

Apopetalous, same as Polypetalous, p. 63.

Apophysis, the swelling at the outer end of the scales of a pine-cone, p. 182.

Appendiculate, with appendages at the throat, p. 78.

Appressed, pressed down on the surface.

Archegonium, the ♀ organ of certain Cryptogams.

Archesporium, the spore-forming cell in the interior of the sporangium, anther-lobe or nucellus, p. 119.

Aril, an extra, usually fleshy and coloured, integument of the ovule.

Arillus, *see* Aril.

Ascending, of an ovule arising obliquely from near the base of the ovary, p. 113.

Astringent, rough to the taste, p. 310.

Atrophy, wasting away from lack of nourishment, p. 27.

Autogamy, when the flower is capable of self-pollination, p. 159.

Awns, small bristle-like appendages.

Axil, the angle between leaf or bract, and the axis bearing it.

Axile, coincident with the axis, p. 115.

Axillary, in the axil, p. 17.

Axis, the parent organ, or an imaginary line representing it, around which organs are developed.

Baccate, berry-like, p. 342.

Barren, infertile, unproductive.

Basal, the lowermost part next the point of origin.
Basifixed, of anthers where the filament joins stiffly at their base.
Berry, a fleshy fruit with small seeds immersed in pulpy placentæ.
Bicarpellary, composed of two carpels, p. 104.
Bi-labiate, two-lipped.
Bilateral, an irregular flower with two planes of symmetry.
Bostryx, a helicoid cyme, p. 35.
Bract, a leaf, usually reduced, subtending a flowering pedicel.
Bracteate, bearing bracts, p. 305.
Bracteole, a small bract between the normal bract and the individual flower.
Branch-tendrils, tendrils shown by origin and position to be branches, p. 291.
Bud-scales, scales enveloping the buds, p. 254.
Caducous, falling very early before the opening of the flower, p. 20.
Calyculus, an outer, secondary, calyx-like covering, formed of bracts.
Calyx, the outer floral envelope.
Calyx-tube, the cup-like hollow of perigynous flowers, from the margins of which the stamens, petals, &c., spring, p. 52.
Campanulate, bell-shaped.
Campylotropous, of an ovule curved on its axis like a horse-shoe, p. 114.
Capitate, with a head-like swelling at the apex, p. 303.
Capitulate, of the nature of a capitulum or head, p. 163.
Capitulum, florets crowded into a head, p. 24.
Capsule, a dry dehiscent fruit, splitting by valves, pores, &c.
Carcerulus, the name sometimes given to the dry indehiscent fruit of the Lime, &c., p. 286.
Carina, the boat-like structure formed by the two inferior petals of a papilionaceous flower, p. 149.
Carpellary scale, the outer of the two scales in the cone of Abietineæ, &c., p. 139.
Carpels, the organs on which the ovules are borne.
Caryopsis, the dry indehiscent fruit of Grasses, &c., p. 273.
Catkin, strictly a deciduous spike bearing unisexual flowers, but somewhat loosely used, p. 25.
Cell, the morphological unit of the plant.
Cellulose, the material of which vegetable cell-walls, membrane, &c., are composed.
Cell-wall, the film separating any two cells.
Centrifugal, the flowers opening in order from the inside of the inflorescence to the periphery.
Centripetal, the flowers opening in order from the periphery of the inflorescence inwards, p. 22.
Chagreened, with a rough almost file-like surface, p. 355.

Chalaza, the organic base of the nucellus, p. 113.
Chalazogamic, where fertilisation is effected by the pollen-tube entering the chalaza instead of the micropyle of the ovule, p. 171.
Chemotropism, a peculiar attraction of organisms for certain chemical substances, p. 169.
Choripetalous, same as Polypetalous, p. 63.
Ciliate, the same as Ciliated, p. 195.
Ciliated, with motile flagella.
Cincinnus, a scorpioid cyme, p. 35.
Cladode, a flattened and leaf-like branch, p. 38.
Claw, the stalk-like narrow base of some petals.
Cleistogamic, pollination occurring within the unopened flowers, which are of simpler construction than the ordinary flowers.
Cohesion, concrescence of organs of like kind, p. 61.
Collateral, side by side, p. 37.
Comose, provided with a tuft of fine silky hairs, p. 205.
Concolor, of the scales of a catkin which are of one colour throughout, p. 205.
Concrescence, growth together into a common whole, p. 38.
Condensation, vertical crowding owing to absence of internodes, p. 57.
Condensed, where the flowers are crowded and sub-sessile, p. 34.
Conduplicate, folded lengthwise, like the leaves of a book, p. 311.
Cone, the flower and infructescence of Gymnosperms.
Connate, joined by common growth, p. 275.
Connective, the continuation of the filament up between the anther-lobes.
Conoid, cone-shaped, p. 207.
Convolute, rolled up so that one half is entirely covered by the other.
Cordate, heart-shaped, p. 203.
Coriaceous, leathery, p. 256.
Corolla, the second or inner floral envelope.
Corona, an accessory appendage at the throat of some corollas.
Corpusculum, Robert Brown's name for the archegonium of the Conifers, p. 120.
Cortex, the general covering of the shoot beneath the epidermis, p. 360.
Corymb, an indefinite inflorescence in which the lower pedicels are longest, bringing the flowers all to or near one level, p. 21.
Corymboid, like a corymb in shape, p. 22.
Cotyledons, seed-lobes, the first leaves of the seedling, p. 46.
Cover-scale, the scale of a catkin, &c., subtending a flower or flowers.
Creeping, growing along the surface of the ground, p. 205.
Crenate, cut into rounded teeth, p. 221.
Cross-fertilisation, where pollen from one flower is transferred to the stigma of another, p. 155.
Cruciate, with the petals arranged cross-wise.

Cuneiform, wedge-shaped, p. 228.

Cupule, the extra investment which springs up around the partial ♀ inflorescences of the Chestnut, Beech, Oak, &c., p. 142.

Cuticularised, with the outer surface converted into cuticle.

Cyclic, in whorls or verticels, and not in spirals, p. 57.

Cyme, an inflorescence of which each branch soon terminates in a flower, and younger buds are developed beneath the older ones, p. 36.

Cymose, cyme-like in part or whole, p. 36.

Cytoplasm, the protoplasmic cell-contents.

Decandrous, with ten stamens.

Deciduous, falling early.

Decussate, opposite, but the alternate pairs at right-angles.

Definite, when the axis is at once arrested by a terminal flower, and a lateral axis continues the growth, p. 31.

Dehiscence, the slitting or opening of a fruit, anther, &c.

Dentate, toothed, p. 193.

Development, the gradual inception and growth of organs, p. 48.

Diadelphous, of stamens grouped in two bundles or clusters, p. 62.

Dialypetalous, same as Polypetalous, p. 63.

Dichasium, a cyme in which two equal branches spring right and left from beneath the terminal flower of the principal axis, and each ends in a flower and repeats the process, &c., p. 31.

Dichlamydeous, with two floral envelopes, calyx and corolla.

Dichogamy, when anthers and stigmas mature at different times, so that the flower is physiologically first ♂ and then ♀; or *vice versa*, p. 159.

Dichotomy, forking, p. 8.

Diclinous, with stamens and carpels in the same flower, usually termed hermaphrodite or bisexual.

Digitate, with leaflets outspread like the fingers of a hand, p. 293.

Dioecism, the ♂ flowers on one plant, the ♀ on another, p. 155.

Diplostemonous, with the stamens twice as many as the sepals, petals, &c., and in their normal position of alternation, p. 86.

Disc, an outgrowth or series of outgrowths at or near the base of the stamens or ovary, generally secreting honey, p. 59.

Discolor, of catkin-scales which are of some pale or bright colour below, and black, brown, &c., at the tips, p. 205.

Displaced, out of its true or normal position, p. 38.

Distichous, in two ranks.

Dome, the growing-point in the flower, p. 49.

Dorsal, the side or part turned away from the axis.

Dorsifixed, of anthers where the filament is attached stiffly at one point in the back.

Double flowers, such as have increased numbers of petals, &c., from the normal, p. 43.

Drepanium, a sickle-shaped cyme, p. 35.

Drupaceous, drupe-like, p. 205.

Drupe, a stone-fruit, p. 178.

Drupel, a little drupe, or drupelet, p. 315.

Dwarf shoots, short shoots, p. 191.

Echinulate, prickly, p. 347.

Egg-apparatus, the totality of nucleated, naked cells at the micropylar end of the embryo-sac in Angiosperms.

Egg-cell, the oosphere: the cell which after fertilisation becomes the embryo.

Eleutheropetalous, same as Polypetalous, p. 63.

Elliptic, oval.

Embryo, the youngest stage of a new plant.

Embryonic, in an early stage.

Embryonic tissue, the still undifferentiated tissue at the growing-point from which organs will be formed, p. 48.

Embryo-sac, the chamber (spore) containing the embryo, p. 121.

Endocarp, the inner layer of a fleshy fruit, p. 267.

Endosperm, the feeding tissue in the embryo-sac.

Entomophilous, pollinated by insects, p. 158.

Epicalyx, the calyx-like series of bracts supplementing the true calyx in some flowers; *see* Calyculus.

Epidermis, the outermost cellular layer.

Epigynous, inserted on the top of the inferior ovary.

Epigyny, with petals and stamens on the disc, or margin of the calyx-tube, above the ovary, p. 60.

Epipetalous, on the corolla-tube or throat, p. 62.

Epiphyllous, on the true leaf-surface, p. 38.

Essential organs, stamens and carpels, p. 4.

Exine, the outer membrane of the pollen-grain.

Exserted, of stamens, &c., which protrude beyond the throat of the corolla, p. 267.

Exstipulate, devoid of stipules, p. 203.

Extrastaminal, outside the whorl of stamens, p. 294.

Extrorse, turned so as to face away from the floral axis.

False axis, a monochasium.

Fan-shaped cyme, a sympodial inflorescence with the branches alternately right and left, and in one plane; *see* Rhipidium, p. 35.

Fascicle, a tuft with cymose development of the flowers.

Female flowers, containing pistils only, denoted by the sign ♀, p. 25.

Fertilisation, joining of ♂ and ♀ nuclei of pollen-tube and oosphere, &c., respectively.

Filament, the stalk of the stamen.
Filiform, thread-like, p. 208.
Fimbriated, fringed, p. 199.
Flaccid, limp, p. 312.
Flask-shaped, pear-shaped, with the narrow tapering part acting as a neck.
Floral apex, the end of the shoot within the flower, p. 49.
Floral axis, the shoot around which the floral organs are arranged, p. 270.
Floral diagram, a conventional figure drawn to show the relations of the floral parts, p. 123.
Floral envelopes, the outermost coverings of the flower: calyx, corolla, perianth, &c.
Floral formula, a conventional short-hand expression of the relations of the floral parts.
Floral leaves, bracts, p. 41.
Floral whorls, the cycles of organs, petals, stamens, &c., of the flower, p. 55.
Floriferous, flower-bearing, p. 8.
Flower, the shoot-apex bearing sporophylls—stamens or carpels respectively, p. 3.
Flower-bud, a bud containing one or more flowers, p. 3.
Free, of organs not attached laterally to organs of like kind, nor up or down to those of unlike kind, p. 58.
Free-central placenta, where the placenta stands up in the centre of the ovary and free from its walls.
Fruit, the ripened carpels bearing seed.
Funicle, the stalk of an ovule.
Furcate, forked, p. 233.
Galbulus, the fleshy cone ("berry") of a Juniper, p. 178.
Gamopetalous, a corolla where all the petals have grown into one common whole, p. 63.
Gamopetaly, with petals concrescent into one common corolla, p. 63.
Gamophyllous, with the parts of the perianth coherent into one whole.
Gamosepalous, where the calyx consists of one whole, p. 63.
Gamosepaly, with sepals concrescent into one common calyx, p. 63.
Geminate, in pairs, p. 305.
Germination, the first period of growth of a spore, seed, &c.
Gibbous, protruding as a pouch.
Glabrescent, almost glabrous, p. 206.
Glabrous, devoid of hairs, p. 205.
Gland, a specialised piece of secretory tissue.
Glandular disc, glandular tissue on the floral axis, p. 298.
Glandular hairs, hairs which secrete honey, oil, or other definite substances, p. 273.

Glaucous, sea-green and usually waxy, p. 183.

Glomerulus, a head with cymose development of the flowers.

Glossy, with polished surface, p. 271.

Growing-point, the very apex of the shoot, p. 48.

Gynandrous, where stigmatic column and stamens adhere and fuse into one.

Gynodiœcious, some plants bearing only pseudo-hermaphrodite ♀ flowers, p. 161.

Gynœcium, the totality of the carpels in one flower: the pistil, p. 43.

Gynœmonœcious, where ☿ and ♀ flowers occur without ♂ flowers on the same plant, p. 161.

Helicoid, coiled like a watch spring, p. 221.

Helicoid cyme, a sympodial inflorescence with the branches all developed on one side, but not in one plane; *see* Bostryx, p. 35.

Hemicyclic, part of the organs in whorls, part in spirals, p. 57.

Herbaceous, green and soft like ordinary leaves, grass, &c.

Heredity, transmission of characters from parents to offspring.

Hermaphrodite, when stamens and pistil occur in the same flower: more accurately termed monoclinous.

Heterochlamydeous, with distinctions evident between calyx and corolla.

Heterogeneous, compounded of unlike kinds, p. 29.

Heterostyled, where the styles of different flowers of the same species differ in length.

Hilum, the scar showing where the seed was attached to its stalk.

Hoary, with grey hairs, p. 317.

Homochlamydeous, with calyx and corolla alike.

Homogamous, flowers all alike, the pollen and stigmas maturing simultaneously.

Homogeneous, compounded of like kind, p. 29.

Hump, a little outgrowth on the side of a growing point, destined to become an organ, p. 50.

Hydrophily, pollination by means of water, p. 156.

Hypanthodium, the hollow receptacle of the Fig, p. 270.

Hypha, the filament of a fungus.

Hypogynous, with the parts inserted on the floral axis beneath the ovary.

Hypogyny, with the sepals, petals, and stamens inserted on the floral axis beneath the pistil, p. 58.

Ideal, imaginary, but based on comparisons and reflections on normal cases.

Imbricated, where the edges of the folded organs overlap in bud.

Immersed, plunged or buried in the tissues, p. 265.

Incept, the earliest stage of a developing organ, p. 49.

Indefinite, where the apex grows on continuously and developes new flowers on its flanks, p. 19.

Indehiscent, not naturally splitting open when ripe.
Inferior, of an ovary so retarded in development that the calyx-tube or floral axis, bearing the insertions of petals and stamens with it, grows up and over it.
Inflorescence, the floral branch-system, p. 8.
Innate, of an anther with the filament inserted merely into its base.
Integument, a cell-layer covering the nucellus of the ovule.
Internodes, the stretches of shoot between the nodes, p. 46.
Interrupted, the order destroyed by the interposition of dissimilar organs, p. 27.
Intine, the inner membrane of the pollen-tube.
Introrse, of an anther so turned as to face the floral axis.
Involucre, the bracts crowded, or at one level, round the base of a capitulum, umbel, &c., p. 24.
Involute, with both margins rolled inwards towards the midrib, p. 322.
Irregular, with disturbance in the symmetrical radial arrangement of the parts.
Irritable, responding to touch, &c., by movements, p. 284.
Isobilateral, capable of division in two planes into symmetrical halves.
Isostemonous, with stamens equal in number to the lobes of the corolla, &c.
Keel, the boat-shaped pair of basal petals in a papilionaceous flower.
Laciniate, cut into a fringe at the margin, p. 199.
Lamellated, layered.
Lamina, the blade of a leaf, p. 286.
Lanceolate, narrow and tapering to both ends, p. 203.
Lateral plane, the section of a lateral flower parallel to the earth's surface, p. 123.
Latex, milk-like juice, p. 229.
Leafy raceme, with the bracts so little different from ordinary leaves that the flowers appear singly in the leaf-axils, p. 18.
Legume, the monocarpellary pod of the Papilionaceæ and their allies.
Ligulate, provided with ligules.
Ligule, membranous appendages at the junction of limb and claw, p. 207.
Limb, the broad part or lamina of a petal, &c.
Linear, narrow, with parallel edges.
Lip, one of the large lobes of a labiate corolla.
Lobed, cut into segments too large to be termed teeth, p. 203.
Loculi, cavities in an anther or ovary, containing the pollen or ovules respectively.
Loculicidal, splitting along the dorsal walls of the loculi, p. 335.
Lyrate, lyre-shaped.
Macrospore, the larger of the two spores found in certain Cryptogams.
Male, flowers containing stamens only, denoted shortly by the sign ♂, p. 25.

Marcescent, withering and remaining on the plant.
Marginal, on the edges.
Mealy, as if powdered with flour, p. 345.
Median plane, the vertical plane in a lateral flower, p. 123.
Membranous, thin, and like soft paper in texture.
Metamorphosed, altered.
Metamorphosis, change during the course of evolution, p. 45.
Micropyle, the minute orifice between the integuments through which the pollen-tube reaches the embryo-sac, &c.
Microspore, the smaller of the two kinds of spores met with in certain Cryptogams, p. 99.
Midrib, the axial vascular strand of a leaf, &c.
Modification, changes of form, texture, &c., brought about in the course of evolution, p. 45.
Monadelphous, in one cluster or bundle.
Monandrous, having only one stamen.
Monocarpellary, of one carpel only.
Monochasium, a false axis built up of repeated branches, each ending in a flower, and the whole straightened out, p. 30.
Monochlamydeous, with one floral envelope only.
Monoclinous, of flowers containing both stamens and pistil: hermaphrodite, p. 274.
Monœcious, both ♂ and ♀ flowers on the same plant.
Monopetalous, same as Gamopetalous, p. 63.
Monopodium, an axis of one continuous forward growth, p. 9.
Monosymmetrical, with only one plane in which the flower can be cut into symmetrical halves.
Monstrosity, where the structure, shape, &c., depart so seriously from the normal as to obscure the latter, p. 43.
Morphology, the science of form and position as interpreted by the study of development.
Mother-cell, the cell which by further division yields pollen, spores, &c.
Mucilaginous, gum-like, p. 176.
Mucro, a small sharp point, p. 181.
Mucronate, provided with a small sudden sharp point, p. 182.
Multiaxial, with several axes.
Neck-cell, the cell in the neck of an archegonium.
Nectary, a honey-secreting tissue.
Nodes, the places where leaves are attached to the shoot, p. 46.
Nodose, with knot-like swellings, p. 191.
Non-essential organs, sepals and petals, p. 4.
Nucellus, the inner part of the ovule, invested by the integuments.
Nucleus, a special cell-content.

Nutlets, small nut-like fruits, 274.
Obcordate, reversed heart-shaped, p. 189.
Obcuneate, reversed wedge-shaped, p. 274.
Obdeltoid, reversed triangular, p. 189.
Ob-diplostemonous, diplostemonous, but arranged out of the normal regularly alternating order.
Oblique plane, any plane between the median and lateral planes in a lateral flower, p. 123.
Oblong, somewhat longer than oval and the sides more parallel.
Obsolete, all but vanished.
Oosphere, the as yet unfertilised egg-cell.
Organ, any part with definite functions.
Organography, description of the organs, p. 58.
Orthotropous, straight: the axis of the ovule not curved.
Ovary, the box-like enclosure of the ovules formed by the closed carpels, p. 65.
Ovate, egg-shaped in outline.
Ovules, the incipient seeds borne on the carpels.
Ovuliferous scale, the scale which bears the ovule.
Palmate, divided like a hand, p. 238.
Palmatifid, divided into lobes like the hand, p. 225.
Panicle, a raceme of racemes, p. 28.
Papilionaceous, a particular order of flower often resembling a butterfly.
Pappus, the hairy calyx of the Compositæ.
Papyraceous, paper-like, p. 205.
Parasitic, gaining its food-materials from other living organisms.
Parietal, on the walls of the ovary.
Pectinate, comb-like, p. 197.
Pedicel, a lateral stalklet bearing one flower, p. 9.
Pedicellate, on a little stalk, p. 206.
Peduncle, a stalk bearing flowers, p. 9.
Pedunculate, with a definite stalk, p. 350.
Peltate, a shield-like body with the stalk or handle in the middle, p. 135.
Pendulous, suspended from or near the top of the ovary.
Pentacyclic, of five whorls or cycles.
Pentandrous, with five stamens, &c.
Perfect, of a flower having all the floral parts, p. 55.
Perianth, a floral envelope not strictly determinable into either calyx or corolla, p. 129.
Periderm, the corky part of the cortex, p. 195.
Perigone, the name sometimes given to the perianth of a ♀ flower.
Perigyny, with the stamen and petals inserted on the calyx or open calyx-tube, p. 59.

Persistent, remaining on after flowering.
Petal, one of the non-essential organs of a flower, usually delicate and coloured.
Petaloid, like petals, p. 43.
Petiolar glands, glands on the petiole, p. 211.
Petiole, the leaf-stalk, p. 219.
Phyllotaxy, leaf-arrangement on the shoot, p. 56.
Pilose, softly hairy, p. 317.
Pinnate, with leaflets right and left on a main stalk, p. 264.
Pinnatifid, cut in a pinnate fashion.
Pistil, the totality of carpels, p. 43.
Pistillate, flowers or inflorescences bearing carpels only; *see* Female.
Pith, the central tissue of a stem, p. 239.
Placenta, the tissue from which the ovules arise.
Placental scale, the scale of a pine-cone, &c., which bears the ovules, p. 175.
Placentation, the arrangement, &c., of the placentæ.
Plumule, the primary bud of the embryo or seedling, p. 200.
Pod, *see* Legume.
Polished, shining, glossy, p. 268.
Pollen, the powdery mass of spores which is contained in the anthers.
Pollen-grains, the microspores or units of which the pollen consists.
Pollen-sac, the cavity in the anther in which the pollen developes.
Pollen-tube, the germ-tube emitted when the pollen-grain germinates.
Pollination, transmission of pollen-grain to stigma.
Pollinium, a mass of pollen-grains which retain their coherence.
Polyadelphous, in several clusters or bundles.
Polyandrous, with numerous stamens.
Polycarpellary, of many carpels.
Polychasium, like a dichasium but three or more branches arise each time, p. 35.
Polygamous, with ♂, ♀, and ☿ flowers on the same plant, p. 155.
Polymorphic, of several or many shapes.
Polymorphy, showing variations in shape.
Polypetalous, with several separate petals.
Polypetaly, with free petals, p. 63.
Polysepalous, of several separate sepals.
Polysepaly, with free sepals, p. 63.
Pome, a fruit of the apple type, p. 322.
Porogamic, where the pollen-tube enters the micropyle in fertilisation, p. 171.
Primary axis, the main shoot or stalk of the inflorescence, &c., p. 17.
Proliferous, growing forward after a pause, p. 182.
Prostrate, flung on the ground, p. 205.

Protandrous, where the anthers shed pollen before the stigma of the same flower is ready, p. 159.

Proterogynous, where the stigma is mature before the anthers of the same flower, p. 159.

Prothallus, a tissue which nurses the embryo in certain Cryptogams.

Protoplasm, the living substance of the plant.

Protuberance, outgrowth; *see* Hump, p. 51.

Pruinose, with a waxy bloom.

Pseudaxis, *see* Monochasium, p. 13.

Pubescent, softly hairy, p. 189.

Pulvinar, on the pulvinus, p. 301.

Punctate, dotted, p. 278.

Pyriform, pear-shaped, p. 318.

Quincuncial æstivation, a particular case of imbricate æstivation, p. 146.

Raceme, an indefinite, monopodial and acropetal inflorescence, with pedicels of equal length along the peduncle.

Racemoid, like a raceme in shape only, p. 13.

Racemose, of the type of the raceme.

Rachis, the axis of an inflorescence, a compound leaf, &c., p. 206.

Raphe, the vascular strand running up the side of an anatropous ovule.

Receptacle, the dilated end of the peduncle or pedicel which acts as a bed on which the florets or their parts are inserted, p. 24.

Recurved, curved backwards, p. 262.

Reduced, cymes, &c., in which some flowers are missing, or in which the numbers are very small, p. 37.

Reflexed, turned back on its insertion.

Regular, with the parts so arranged round the axis that several planes of symmetry can be found.

Reniform, kidney-shaped, p. 344.

Reticulate, netted, p. 206.

Revolute, with the margins rolled back, p. 219.

Rhipidium, a fan-shaped cyme, p. 35.

Rosaceous, of the floral type of a Rose.

Rotate, wheel-shaped in the limb, the tube very short.

Retund, approximately circular, p. 219.

Rugose, wrinkled, p. 181.

Salver-shaped, like rotate but with a distinct tube, p. 339.

Samara, a winged achene, p. 233.

Scale, a hardened or discoloured bract of a catkin, bud, &c., p. 34.

Scale-leaves, leaves of usually hardened texture, reduced size, and protective functions, p. 46.

Scape, a leafless peduncle inserted below the ground-level, p. 17.

Scarious, brown at the tips and margins as if scorched, p. 176.

Scorpioid cyme, a sympodial inflorescence with the branches developed alternately right and left but not in one plane; *see* Cincinnus, p. 35.
Scrambler, a plant that flings its shoots over others, p. 315.
Secondary axes, branches on a primary axis, p. 34.
Secund, turned all to one side, p. 334.
Seed, the matured ovule containing an embryo.
Self-pollination, where the pollen is deposited on the stigma of the same flower.
Sepal, one of the outermost non-essential organs, usually green and more or less leaf-like.
Sepaloid, like sepals.
Septicidal dehiscence, splitting in the plane of the septa, p. 324.
Septifragal, splitting across the septum, p. 334.
Septum, a partition wall of the ovary, &c., p. 260.
Serrate, toothed like a saw, p. 248.
Serratulate, with little teeth, p. 342.
Sessile, devoid of stalks or pedicels, p. 34.
Setose, bristly, p. 317.
Sickle-shaped cyme, a sympodial inflorescence in which the branches, all on one side and in one plane, form a curved pseudaxis; *see* Drepanium, p. 35.
Solitary, singly in the axil, &c., p. 18.
Spadix, a spike with the axis swollen and fleshy and enclosed in a large bract, p. 25.
Spathe, the bract of a spadix, p. 25.
Spathulate, shaped like an old-fashioned spathula or spoon, p. 207.
Spermatozoid, the fertilising element of certain Cryptogams, &c.
Spicate, spike-like in nature, p. 163.
Spike, as a raceme, but the flowers sessile on the axis, p. 24.
Spikelet, a partial spike.
Spinescent, spiny.
Sporangium, the organ in which spores are formed.
Spore, a cell which becomes free and capable of developing a new plant.
Sporogenous, spore-producing.
Sporophyll, a spore-bearing leaf.
Spurred, with a spur-like prolongation.
Stamens, the organs which contain the pollen or microspores.
Staminal, appertaining to the stamens, p. 267.
Staminate, flowers or inflorescences consisting of stamens only; *see* Male.
Standard, the posterior petal in a typical papilionaceous flower, p. 149.
Stigma, the receptive organ on which the pollen is deposited and germinates.
Stipule, an appendage at the base of the petiole.

Stoma, an opening in the leaf to admit and regulate the passage and exchange of gases and vapour.
Striate, streaked, p. 189.
Style, the organ intervening between ovary and stigma in many Angiosperms.
Subulate, shaped like an awl, p. 175.
Superficial, placentæ on the surface of the carpels.
Superior, of an ovary with the stamens, &c., inserted on the floral axis below it.
Superposed, one above the other.
Suppression, non-development of an organ normally present, p. 35.
Suspended, of an ovule hanging from the top of the chamber of the ovary.
Sutural, where the placenta obviously coincides with the coalesced margins of a monocarpellary ovary.
Suture, the line of cohesion or of the midrib of a carpel.
Sympetalous, same as Gamopetalous, p. 63.
Sympodium, an axis composed of interpolated portions, and not truly continuous, p. 13.
Syncarpous, with the carpels cohering into a common ovary, p. 65.
Synergidæ, the two naked nucleated cells which flank the oosphere in the embryo-sac.
Syngenecious, with connate anthers.
Tapetal, appertaining to the tapetum.
Tapetum, a peculiar layer of cells surrounding young spores, and ultimately absorbed by them.
Tendril, a thread-like climbing organ, p. 277.
Terete, cylindroid but slightly tapering, p. 320.
Tetramerous, in fours or multiples of four, p. 267.
Tetrastichous, in four rows, p. 181.
Theca, the anther.
Throat, the aperture of a corolla tube.
Thyrsus, a panicle-like inflorescence, the branches of which pass into cymes, p. 36.
Tomentose, loosely or woolly haired, p. 206.
Tomentum, loose cottony or woolly hairs, p. 215.
Torsion, twisting, p. 39.
Torus, bed of the flower on which the carpels, stamens, &c., are inserted; *see* Receptacle, p. 55.
Transitional, inflorescences partaking of the character of both racemose and cymose types, p. 37.
Tricarpellary, of three carpels.
Trifoliolate, of a leaf, &c., with three leaflets, p. 304.
Trifurcate, three-pronged, p. 277.

Trigonal, with three angular edges, p. 252.

Trimethylamine, a peculiarly smelling organic substance found in herrings, &c., and in certain flowers, p. 321.

Tubular, drawn out to a tube.

Turbinate, top-shaped, p. 229.

Two-lipped, *see* Bilabiate.

Typical, affording a fair example.

Umbel, an indefinite inflorescence with pedicels of equal length radiating from one centre, p. 23.

Umbellate, of umbel-like shape, p. 39.

Umbo, the small projection on the apophysis of many pine-cones, p. 182.

Uniaxial, with one axis.

Unisexual, a name commonly but, strictly speaking, erroneously used for diclinous flowers.

Urceolate, urn-shaped, p. 205.

Vacuole, a sap-drop in the cell.

Valvate æstivation, when the margins of the parts in the flower-bud are merely in contact, p. 147.

Valvular, opening by valves.

Vascular bundle, a group of vessels, sieve-tubes, &c.

Velvety, *see* Villose, p. 215.

Venation, the totality of vascular strands in the leaf, &c.

Venter, the basal part of an archegonium.

Ventral, nearest the axis.

Ventral canal-cell, a peculiar cell at the base of the neck of an archegonium.

Verrucosities, slight wart-like roughnesses, p. 235.

Versatile, of an anther with the filament so inserted that the anther dangles in the wind.

Verticillaster, a false whorl due to two opposite axillary groups of flowers meeting round the node, p. 34.

Vexillum, same as Standard.

Villous, with velvet-like hairiness, p. 221.

Viscin, the sticky matter of the fruit of the mistletoe, p. 266.

Whorl, where three or more organs are inserted round the axis at the same node, p. 46.

Wing, a flattened appendage to a fruit, seed, &c. Also the lateral petal of a papilionaceous flower; *see* Alæ, &c.

Zygomorphic, with the planes of symmetry such that the flower can only be once cut into corresponding halves.

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